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A LORAN-C CALIBRATION, THE WEST CANADIAN CHAIN CYCLE SELECTION TESTS

by
A.R. Mortimer



Canada
INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY
Sidney, B.C.

1979

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ABSTRACT

This report describes a series of user oriented Loran-C cycle identification tests made for the West Canadian Chain. The weakness of Loran-C coverage in Juan de Fuca Strait and in Dixon Entrance is demonstrated.

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| Mr. G. Fernandes | N.O.A.A., Seattle |

LORAN C COVERAGE IN THE NORTH EAST PACIFIC

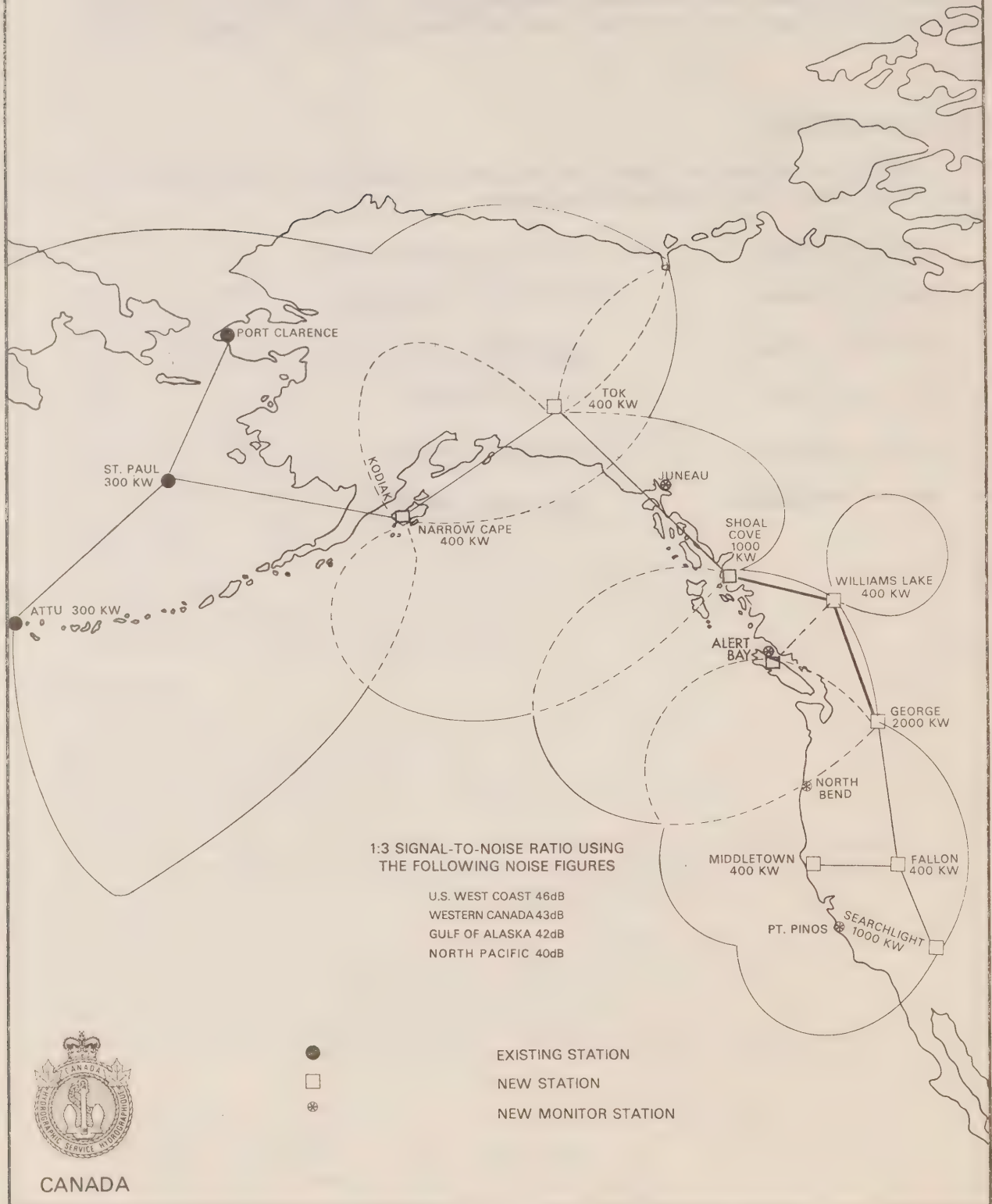


Figure 1

INTRODUCTION

The Canadian Hydrographic Service (C.H.S.) conducted a calibration of the West Canadian Loran-C Chain in the spring of 1977 (see Figure 1). This calibration was primarily designed to provide accurate lattices for Loran-C charts of the British Columbia (B.C.) coast.¹ However, as the C.H.S. also provides practical information for the mariner in the form of sailing directions and other publications, it was thought that a more general evaluation of the chain would be of interest. Therefore an experiment, secondary to the main calibration, was designed to assess one important aspect -- cycle identification -- of Loran-C operations from the new user's viewpoint.

To make the assessment of the chain's cycle identification capabilities, a number of commercial Loran-C receivers were lent to the C.H.S. by local companies. The actual tests were made by simply turning on the receivers and seeing if they accurately acquired the Loran-C signal. This first set of tests was made over all of the B.C. coast (see Figure 2). They served, together with data from a United States Coast Guard (U.S.C.G.) monitor receiver used in the calibration ship, to define areas of poor Loran-C reception at the entrance to Juan de Fuca Strait and in Dixon Entrance.

Loran-C has many applications which call for varying degrees of absolute accuracy and of repeatability. However, all users require that their Loran-C receivers accurately, and in some cases quickly, acquire and track the zero crossing point of the third cycle of the pulse in three of a chain's transmissions. A cycle identification error, in one of the transmissions used to generate a hyperbolic position line, produces a 10 microsecond shift in that position line. This displacement is almost always high, (i.e. the time of arrival (T.O.A.) of the pulse is increased) and can, quite often exceed 10 microseconds in further increments of 10 microseconds to 20 or more microseconds. Land path from the transmitters distorts the Loran-C pulse and makes such errors more likely, particularly at a long range. The land path to the two problem areas, Dixon Entrance and Juan de Fuca Strait, from the farthest transmitters is greater in the West Canadian Loran-C chain than in any earlier Loran-C chains. Cycle selection capabilities also tend to deteriorate where local "noise" interferes with the process. Precipitation static, proximity of other transmitters using frequencies near 100 KHz and even twilight effects can have detrimental results on the cycle selection process when the Loran-C signal is already attenuated by a long land path.

Off Dixon Entrance, if a receiver makes a +10 microsecond error in acquiring and tracking the transmission from George, Washington, then the user's apparent position will be shifted about 5 nautical miles (n.m.), east-north-east. Off the entrance to Juan de Fuca Strait, if the Shoal Cove, Alaska, transmission is acquired and tracked 10 microseconds high, then the user's apparent position would be shifted $1\frac{1}{2}$ n.m. east-north-east. Such a shift of position would be confusing to a navigator, even when a radar fix is available for comparison.

The first calibration was made before the chain was commissioned, and at this time envelope to cycle difference (E.C.D.) was not rigorously

C.S.S. PARIZEAU
LORAN-C CALIBRATION

NORTH BOUND FROM VICTORIA -----

SOUTH BOUND FROM MASSET _____

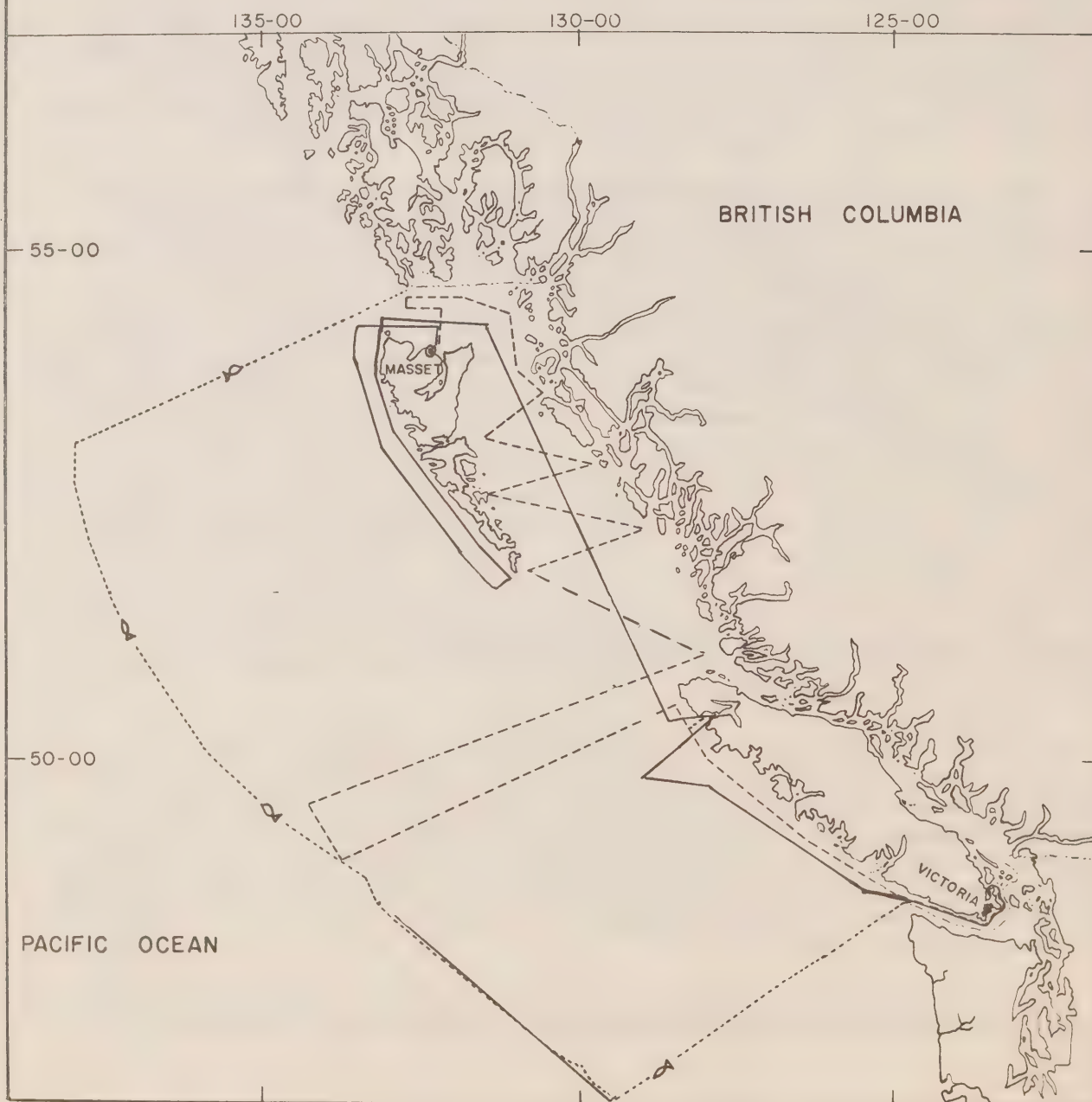


Figure 2

controlled.² After commissioning, the cycle numbers of the Alert Bay monitor for the West Canadian Chain were held at 2.93, 2.83 and 3.03 for Master (Williams Lake), X (Shoal Cove) and Y (George, Washington) trans-missions respectively.

The West Canadian Chain made its debut in court, in November 1977, where a Russian trawler skipper was prosecuted for fishing in a closed area on La Perouse Bank. The prosecution, which was unsuccessful, relied partially on Loran-C positions as evidence.³ After the trial, the U.S.C.G. made a series of cycle identification tests in Puget Sound, Georgia Strait and through Juan de Fuca Strait as far as La Perouse Bank, off the west coast of Vancouver Island. The results of the U.S.C.G. cycle identification tests on La Perouse Bank were "outstanding". The one recommendation of the U.S.C.G. report was that the Canadian Government be advised to conduct another cycle identification survey in the area. Such a survey was made in November 1978, making cycle identification tests with five commercial Loran-C receivers. Regretably, the results were not outstanding.

Another set of measurements was made in September 1978 when National Ocean Survey (N.O.S.) and U.S.C.G. calibrated the U.S. West Coast Chain in Juan de Fuca and Haro Straits. The C.H.S. took this opportunity to make some Loran-C signal quality measurements in Juan de Fuca Strait for both the Canadian and U.S. West Coast Chains. These measurements were made in N.O.S. Ship *MacArthur* with an Austron 5000 Monitor Receiver. Cycle identification tests were not made at this time, but the two Internav 204 receivers used in the calibration, tracked the U.S. West Coast chain throughout the operation.

CYCLE IDENTIFICATION TESTS, SPRING 1977

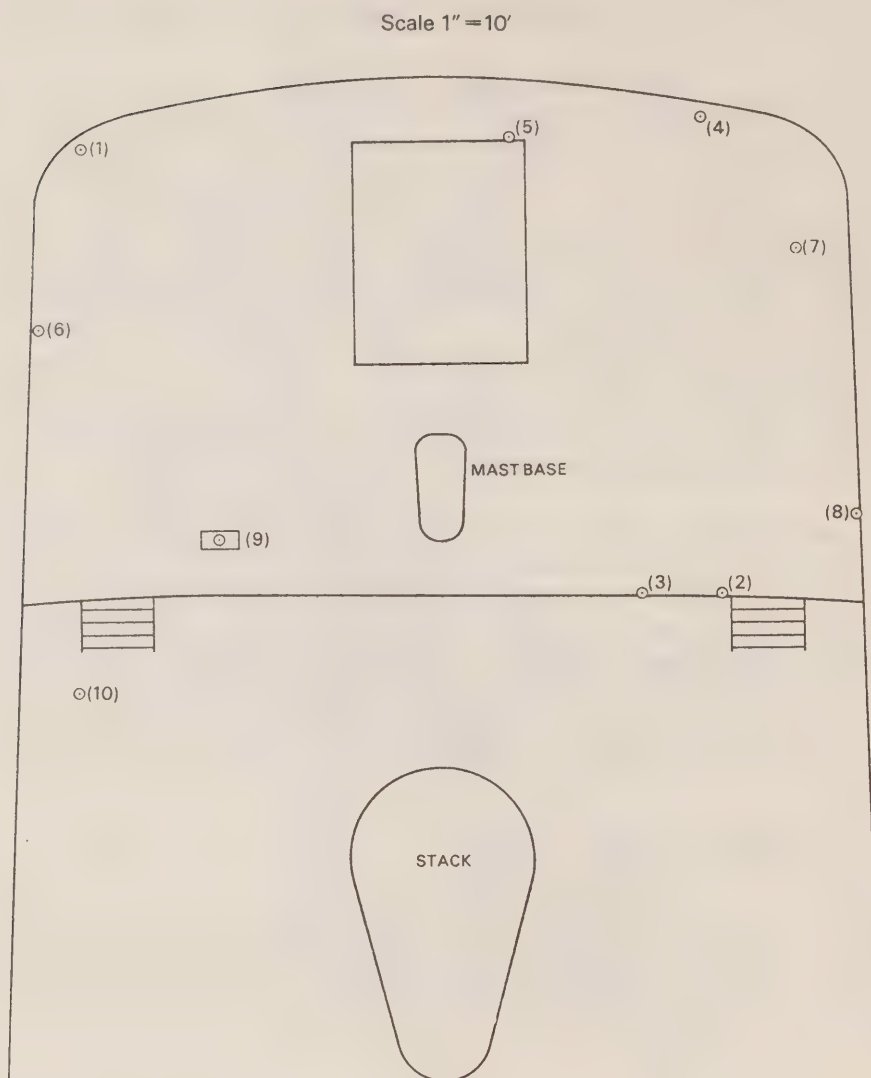
Object: To define from the users' viewpoint the cycle identification capabilities of the West Canadian Loran-C chain. The experiment was not a receiver evaluation. The experimental model was set up to include the variables of receiver type, range and transmission path type from the transmitters.

Equipment: The experiment was conducted from two ships, C.S.S. *Parizeau* (Capt. E. Fisher) and C.S.S. *Vector* (Capt. J. Marston), in March and April, 1977.

On board *Parizeau* four commercial receivers were used for tests. These were a North Star 6000 (NS 6000), a Mirologic 200 (ML 200), a Decca (DL 91) and an Internav (IC 204). The latter receiver is owned by the C.H.S., and the other three were generously lent by their local manufacturers' agents. A list of manufacturers' specifications for these four receivers is given in Appendix 1.

To provide a basis for comparison, two Austron 5000 Loran-C systems were kept continually tracking and monitoring the signals. One of these two Austrons was a monitor system on loan from the U.S.C.G. and it provided signal to noise ratio, gain/field strength and cycle tracking information, as well as basic position data. These two specialized Loran-C receiver systems were used for the main calibration experiment in conjunction with a satellite navigation receiver.

CSS Parizeau Loran-C Antenna Locations



LEGEND

ANTENNAE

- (1) US Coast Guard
- (2) Bedford Institute
- (3) Internav LC 204
- (4) Decca LC DL 91 Mk2
- (5) North Star 6000 DMEC
- (6) Micrologic ML 1000
- (7) ML 200
- Located at cross trees
- (8) Radio telephone 2-3 mHz xmtr
- (9) trunk for 4 span horizontal 25mHz to 400 kHz xmtr
- (10) 2620 to 16mHz xmtr

NOTE Average height above water for the antenna bases is 34'.

Figure 3

In *Vector* only two commercial receivers were used, the Decca DL 91 and the Internav LC 204. Again the U.S.C.G. Austron monitor system was maintained in synchronization with the transmitter stations throughout the time spent in this ship.

The U.S.C.G. monitor system consists of an Austron 5000 Loran-C receiver controlled by a PDP 8/e computer. A Silent 700 data terminal with tape cassette unit is used for input/output. In addition to measuring the T.O.A.'s and time differences (T.D.'s) this monitor system measures receiver gain, T.O.A. variance, which is related to ambient noise, and cycle number which is related to E.C.D. The pulse train or individual pulses from a transmitter in use can be displayed on a scope. The cycle number is of particular interest in this test as it confirms that the Austron T.D.'s were correctly obtained from the third cycle measurements. This cycle number is derived from a ratio of cycle amplitudes in the leading part of the pulse and conveniently indicates the distance into the pulse at which the cycle identification was made. The gain used by the Austron is also of interest in this series of tests as it can be related to field strength by -

$$\text{Field Strength } (\mu\text{volt/metre}) = 50 \times 10^{((110 - \text{Gain\#})/20)}.$$

The antennae for the various receivers were placed above the bridge on both of the ships used. They were sited to maximize spacing between the antennae, in an attempt to meet manufacturers' specifications within the limited space available (see Figure 3). On both ships the receivers were placed in the scientific laboratory and about a 100 ft cable run from the antennae. The DL 91 and LC 204 had preamplifier units at their antennae bases, the other two receivers had passive antennae. The Internav LC 204 receiver was supplied with an auxiliary notch filter designed to eliminate interference from CKN transmissions at 110.75 Khz. The other receivers had only the notch filters supplied as integral parts.

Method: The variables influencing Loran-C signal acquisition were simplified for the purposes of this experiment and the effects of;

- (1) Type of receiver,
- (2) Area of operation,
- (3) Nearband interference,
- (4) Transmitter pair (TD-X, TD-Y), and
- (5) Time to acquire,

were considered. The response was the error of the time difference displayed by the receiver.

Of the four commercial receivers in *Parizeau* only two completed the tests in satisfactory working order. The data produced by the ML 200 was not used in the analysis. The NS 6000 performed well for the first five days of the tests, but then developed a fault in the antenna base or antenna cable. The remaining two receivers were used to generate data for analysis.

As the prime responsibility of the C.H.S. is charting, the areas of operation for the tests were defined by chart limits (see Figure 4). These areas are not of equal size, either in area or in number of tests made within their boundaries. However, the number of tests made within each area was adequate to generate sufficient statistics to describe the system in the area and to enable comparison with other areas.

The *Parizeau* left Patricia Bay on March 21st, 1977 and returned on April 6th, having sailed along much of the outer B.C. coast. Tests were started in Esquimalt Harbour at noon on the 21st of March, and then at approximately hourly intervals throughout the voyage, both in port and at sea.

The procedure for the tests was simple. The watchkeeper, a hydrographer, either, (a) set the notch filters to the best of his ability to eliminate interfering signals, or on alternate tests, (b) set all the notches off the signal, at the extremes of their settings.

The receivers to be used for the tests were then turned on simultaneously, and the time noted. When all the cycle search indicator lights had gone out on any particular receiver and that receiver indicated that it was accurately tracking the signal, the time was again noted. The hyperbolic coordinates given by the U.S.C.G. monitor system were also noted. If a receiver (or receivers) had not indicated successful acquisition within thirty minutes the test was stopped. The receiver make and area of operation were logged as well as the time and coordinate information.

In *Vector* a similar series of tests was made to compare the cycle identification capabilities of the West Canadian Chain and the West Coast U.S.A. Chain. The *Vector* sailed from Patricia Bay on the 18th of April and returned on the 22nd. Tests were made during the daylight hours in two areas; (1) Haro Strait, Gulf Islands and Southern Georgia Strait, and (2) Northern Georgia Strait and Howe Sound. Again two commercial receivers were used, the Internav 204 and the Decca DL 91, and the U.S.C.G. monitor system was kept in continuous synchronization with both the West Canadian and West Coast U.S. Chains, providing a basis for comparison. In this set of tests, owing to the proximity to the CKN (110.75 Khz) transmitter in the Fraser Valley, the notch filters were set for all tests, to the best of the operator's ability. Apart from the notch filter settings the tests were conducted in a similar manner to those in *Parizeau*. Six complete sets were made each day. This amounted to fifty or more signal acquisitions on each chain. Throughout the *Vector* tests, the signals from the two west coast chains were acquired alternately.

Data: The data for the first operations in *Parizeau*, are tabulated in Appendix 2. The distribution of times taken to acquire the signals is shown in Figures 5 and 6. The data summarizing the number of cycles displaced for the tests in Areas 2 and 8 are shown in Figure 7. Appendix 3 contains data obtained in *Vector*, where the U.S. and Canadian chains were compared in the Strait of Georgia. This appendix also contains field strength and signal to noise ratio measurements made in *Vector*.

Discussion: In the analysis of the data from the first series of cycle

CHARTING AND TEST AREAS B.C. COAST

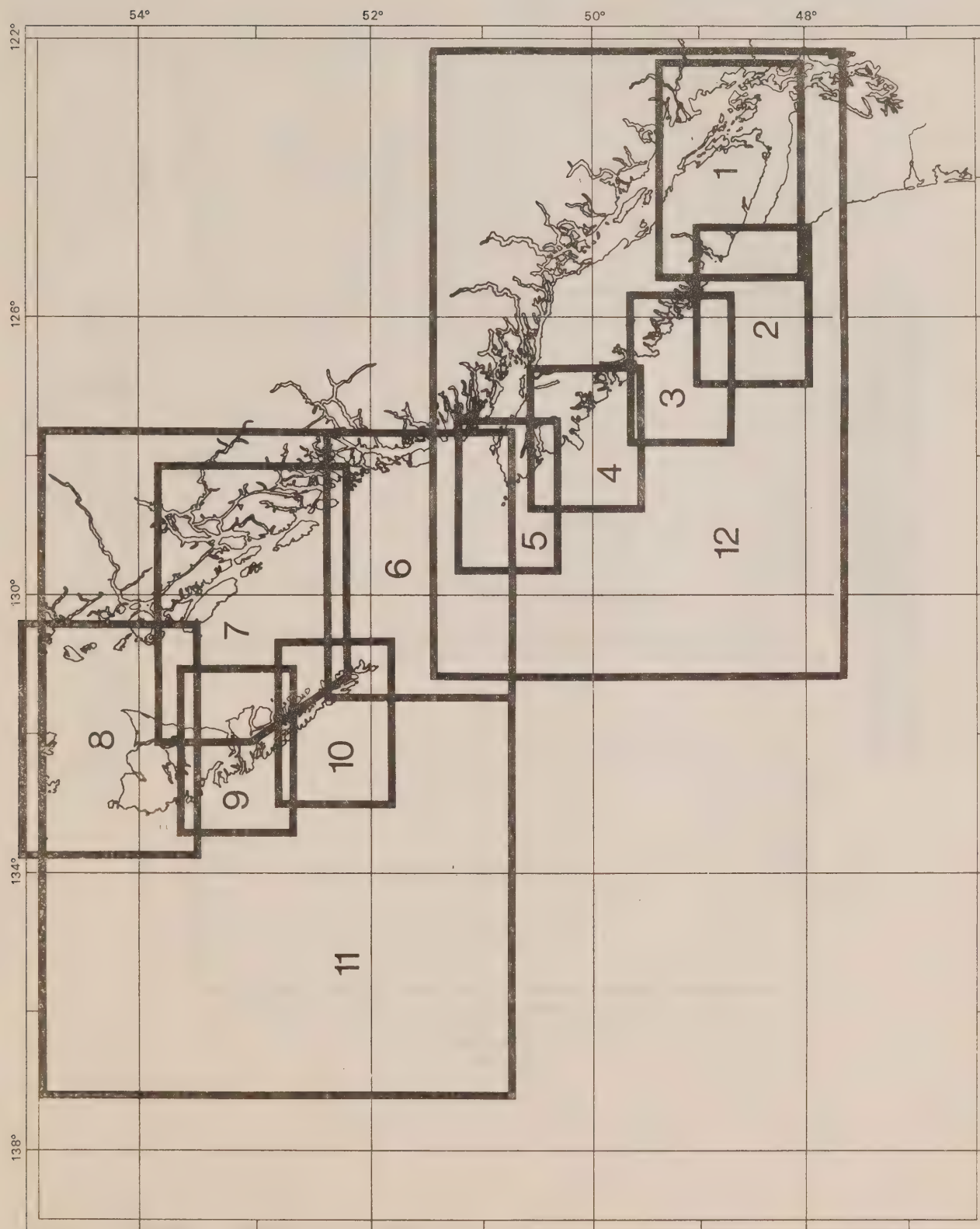


Figure 4

RELATIVE FREQUENCY OF TIME TAKEN TO INDICATE ACQUISITION OF SIGNAL (1)

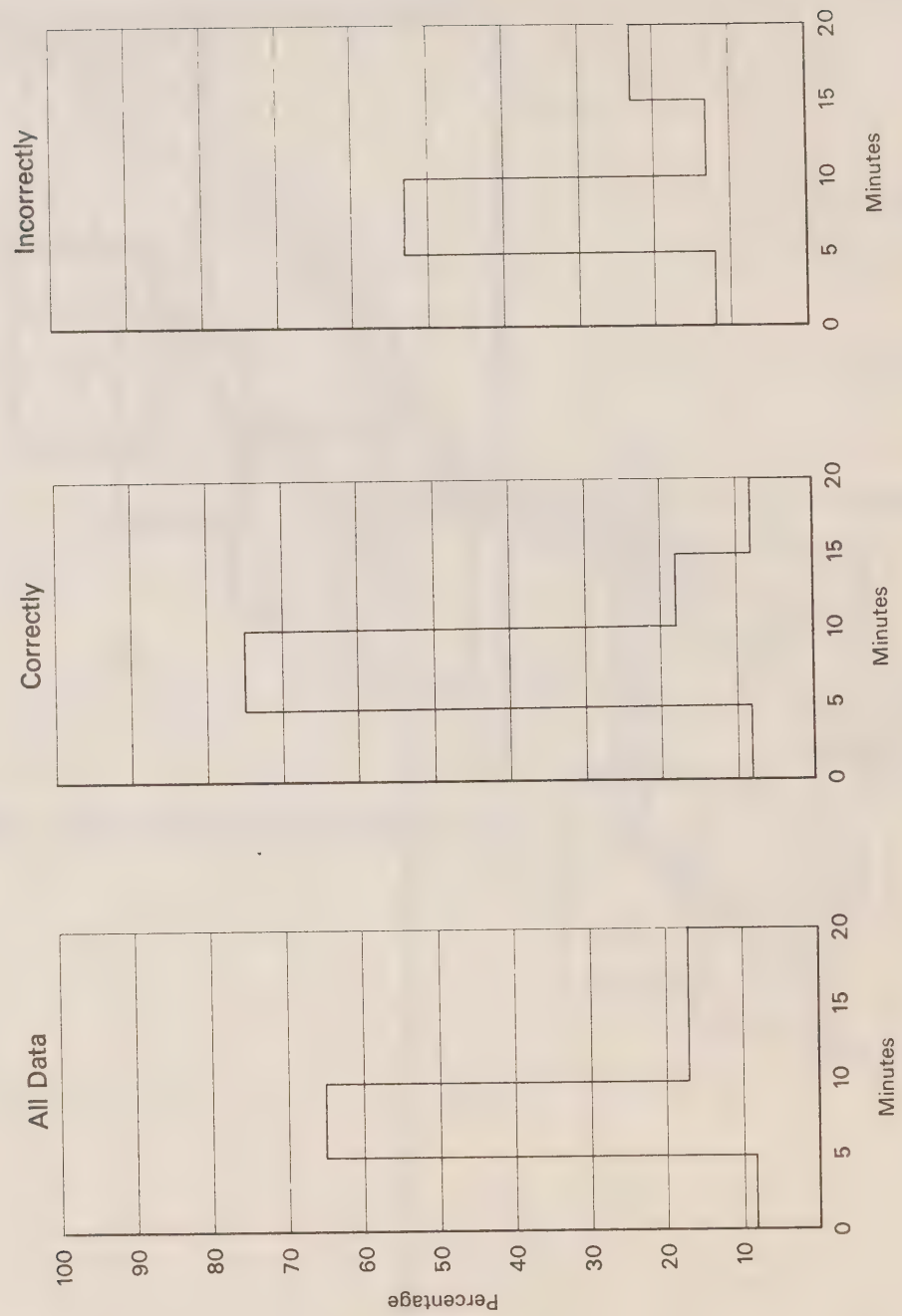


Figure 5

RELATIVE FREQUENCY OF TIME TAKEN TO INDICATE ACQUISITION OF SIGNAL (2)

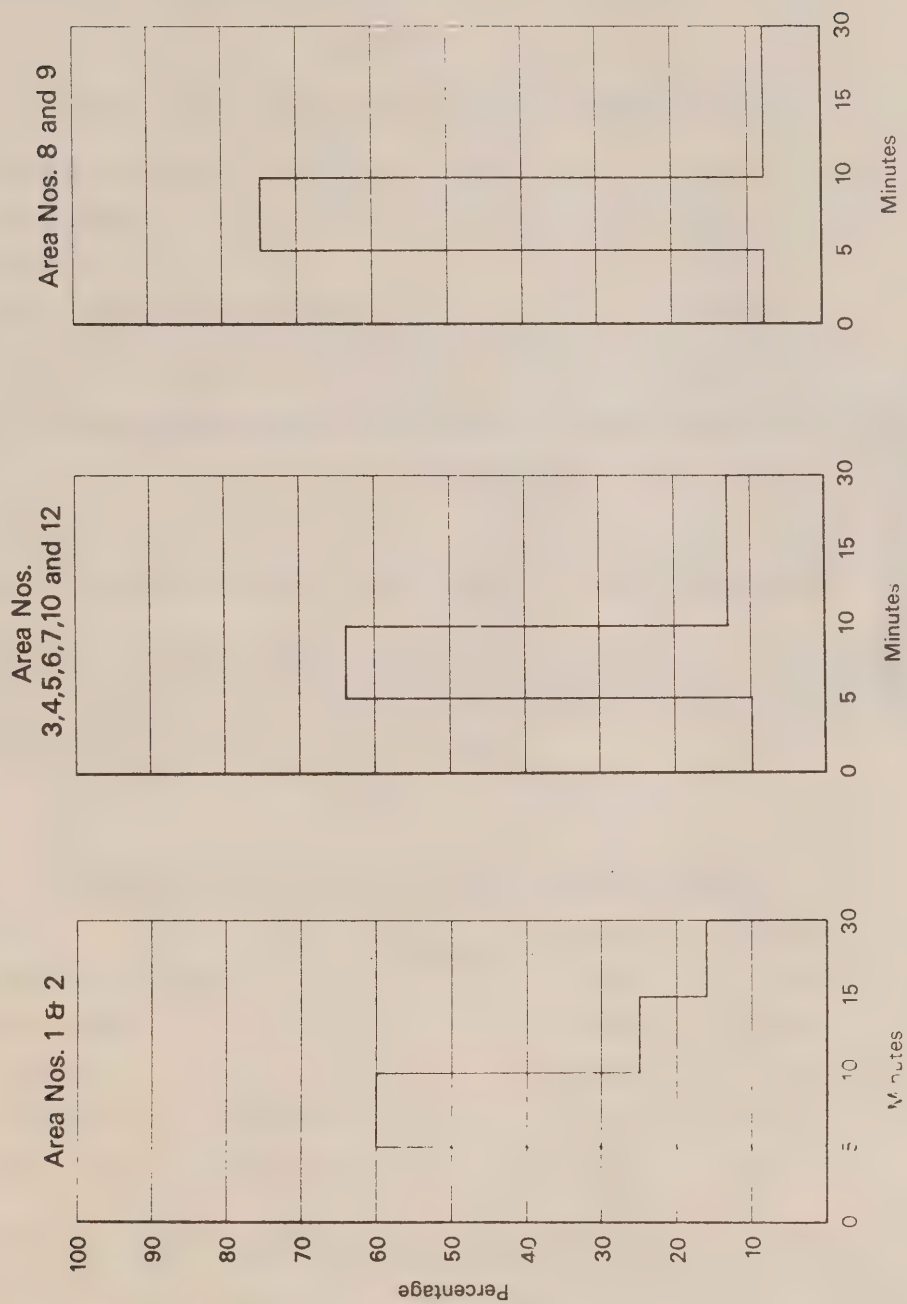


Figure 6

JUAN DE FUCA STRAIT AND DIXON ENTRANCE RELATIVE FREQUENCY OF ACQUISITION ERRORS

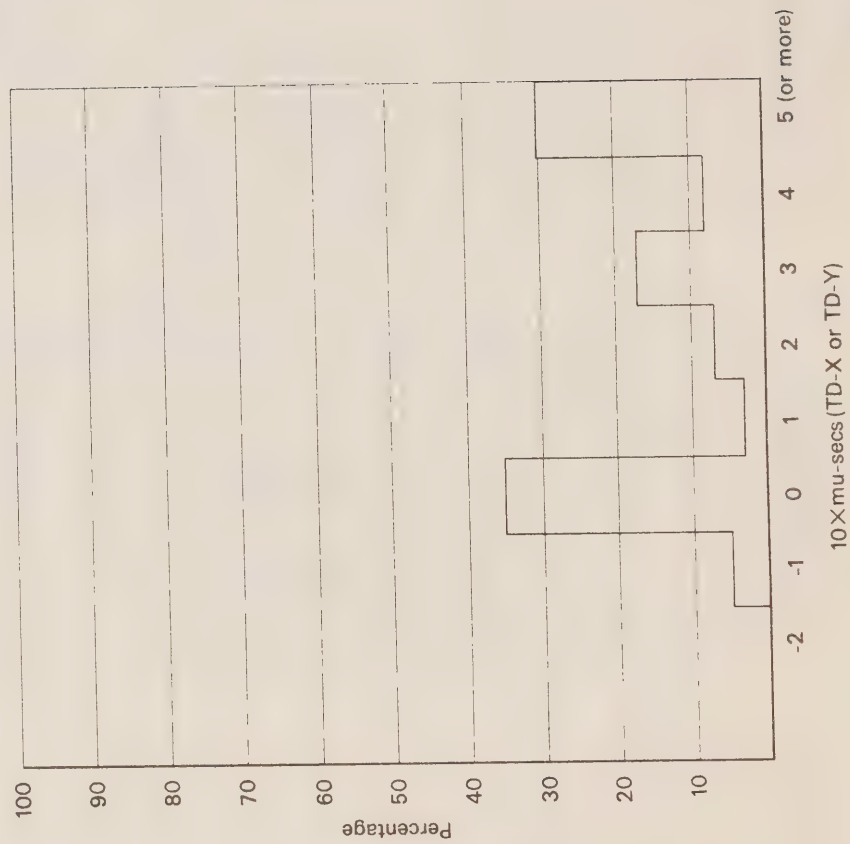


Figure 7

identification tests, the error in the T.D. pair displayed by a receiver was treated as having a Bernoulli distribution. That is, the receiver either successfully acquired the correct cycle and gave correct coordinates on both patterns or it failed to acquire one or both T.D.'s. This approach is rather austere, but this is how an inexperienced user sees a system - either it works or it doesn't. So, using data from the tests made in the spring of 1977, in all areas, with or without notch filtering, using two receivers, for the West Canadian Chain:

Table 1

Summary of Overall Test Results, Spring 1977

| | |
|------------------------------|-------|
| Number of Tests | 545 |
| Successes | 338 |
| Failures | 207 |
| Proportion of Successes | 0.62 |
| Std. Dev. of this Proportion | ±0.02 |

Here the standard deviation (Std. Dev.) of the proportion is calculated using:

$$\text{Std. Dev. of Proportion} = \sqrt{\frac{p(1-p)}{n-1}}$$

where p is the proportion of successful trials and n is the number of trials. This standard deviation is useful when comparing two proportions.

Again, looking at the chain as a whole, it is necessary to consider if the type of receiver used could influence the results of the experiment. So this description uses all tests made in the spring of 1977, in all areas, with or without notch filters, on both ships.

Table 2

Receiver Performance Results, Spring 1977

| | DL 91 | LC 204 |
|------------------------------|-------|--------|
| Number of Tests | 271 | 274 |
| Successes | 144 | 194 |
| Failures | 127 | 80 |
| Proportion of Successes | 0.53 | 0.71 |
| Std. Dev. of this Proportion | ±0.03 | ±0.03 |

The question was then asked, "Is the probability of successful signal acquisition the same for both receivers?" On inspection of the data it is intuitively obvious that there is a difference and, using the standard deviation, this is confirmed statistically, as it can be stated that there is only a 38% chance of both receivers performing in the same manner. Thus the receiver type does have an effect on the experiment and the use of two receivers will minimize the effect on the assessment of the chain.

To see if the two transmitter pairs, Williams Lake - Shoal Cove (TD-X) and Williams Lake - George, Washington (TD-Y), have similar cycle identification capabilities throughout the calibration area, we have: -

Table 3

Time Difference Test Results (5990)

| | <u>TD-X</u> | <u>TD-Y</u> |
|-------------------------|-------------|-------------|
| Number of Tests | 545 | 545 |
| Successes | 423 | 428 |
| Failures | 122 | 117 |
| Proportion of Successes | 0.78 | 0.79 |
| Std. Dev. of Proportion | ±0.02 | ±0.02 |

This tabulation includes the effects of data from all areas, with or without notch filtering, on both receivers and in both ships. The table shows that when averaged over the calibration area, the transmitter pair has little or no effect on the system's cycle identification capabilities. This can be shown to be due to poor reception of TD-X in Area #1, Juan de Fuca and Georgia Straits, being balanced by equally poor reception of TD-Y in area #8, Dixon Entrance.

Southern B.C. Coast

It is worthwhile considering the tests from an areal viewpoint. Areas #1 and #2 off southwestern B.C. have the heaviest concentration of traffic on the west coast of Canada. The Pacific Pilotage Authority boarded 3920 ships off Victoria and 219 off Cape Beale in 1976. These numbers represent about half the foreign ship movements through Juan de Fuca and Georgia Straits and do not include warships, coastal traffic, tugs, fishboats or bathtubs. Neither do they include any traffic proceeding to or from United States ports. Area #8 covers Dixon Entrance and the Triple Island pilotage station where 393 ships were boarded by members of the Pacific Pilotage Authority. These two areas have the greatest traffic density on the B.C. coast. Although the waters off southwestern B.C. are by far the most heavily used, the approaches to Prince Rupert and to other northern ports are also of great importance.

In Area #1, inside the entrance to Juan de Fuca Strait, the probability of correctly acquiring the transmissions needed to derive TD-X is low.

Table 4

Results* of Tests in Area #1

| | <u>TD-X</u> | <u>TD-Y</u> |
|-------------------------|-------------|-------------|
| Number of Tests | 83 | 83 |
| Successes | 29 | .82 |
| Failures | 54 | 1 |
| Proportion of Successes | 0.35 | 0.99 |
| Std. Dev. of Proportion | ± 0.05 | ± 0.01 |

*Tests made without the notch filters set are not included in this data set.

Table 5

Field Strengths in Area #1

| | |
|-----------------|----------------------------|
| (1) Master | abt. 1200 microvolts/metre |
| (2) X-Secondary | 14-24 microvolts/metre |
| (3) Y-Secondary | abt. 6200 microvolts/metre |

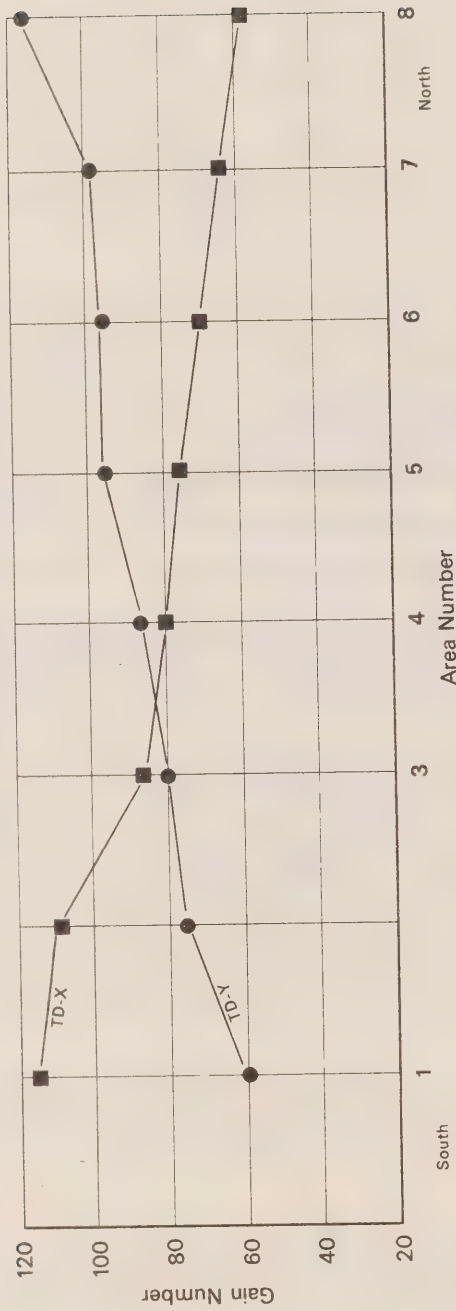
These field strengths, which are derived from monitor receiver gain numbers, show a great range, and can be correlated with the success rate of the acquisition data (see Figure 8).

The gain number of the secondary transmissions forming the time difference and probability of successful signal acquisition of that T.D. have a 75% correlation. Also, from practical experience, using the U.S.C.G. monitor system at sea, when field strength rises to above 150 microvolts/metre (gain # ≤ 100), an "average" Loran-C receiver will reliably acquire a signal. When field strength falls below 50 microvolts/metre (gain # ≥ 110), it is doubtful if an "average" receiver will even track a signal. At the time of the tests CKN was intermittently making pulsed transmission at 110.75 Khz. CKN's frequency has since been moved to 124 Khz.

In general, cycle identification is a function of signal strength, signal to noise ratio, and envelope to cycle difference; and all these factors will vary along the transmission paths from both the master and the secondary transmitter.

The use of notch filters appeared to be essential during the spring of 1977 in Area #1. Only six tests were attempted without the notch filters set and all of these were failures. In the tests conducted in both *Vector* and *Parizeau*, there was no indication of any major differences in the cycle identification capabilities of the two receivers used. The best results in this case came from the DL 91 with a 40% ($\pm 8\%$) success rate.

GAIN NUMBER (FROM MONITOR RECEIVER) vs. AREA



% SUCCESS IN TESTS vs. AREA

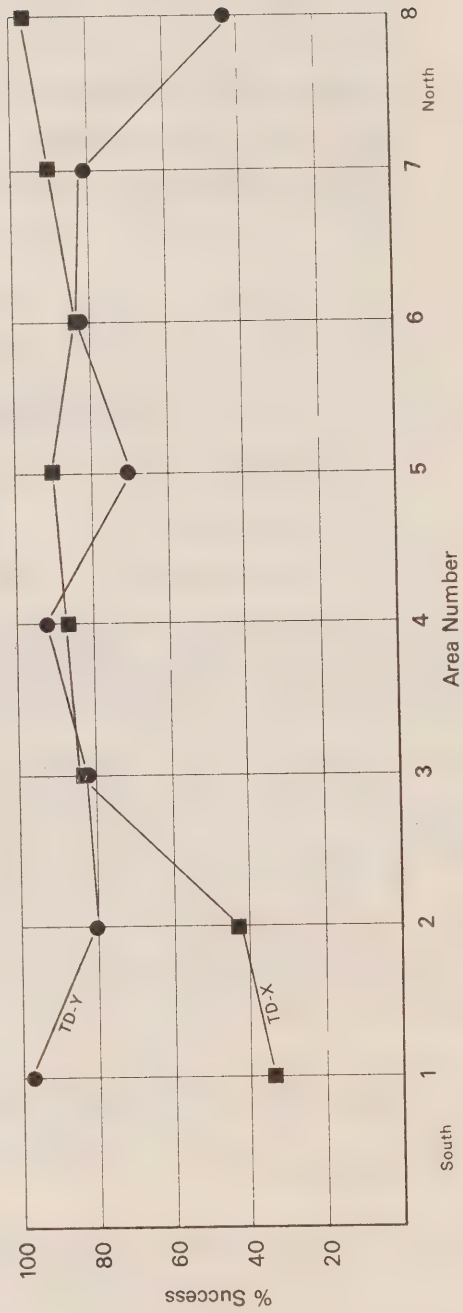


Figure 8

In Area #2, outside the entrance to Juan de Fuca Strait the tests were a little more successful than those inside.

Table 6

Results of Test in Area #2

| | <u>TD-X</u> | <u>TD-Y</u> |
|-------------------------|-------------|-------------|
| Number of Tests | 38 | 38 |
| Successes | 16 | 31 |
| Failures | 22 | 7 |
| Proportion of Successes | 0.42 | 0.82 |
| Std. Dev. of Proportion | ± 0.08 | ± 0.06 |

In this area, the two receivers used showed markedly differing cycle identification capabilities. However, the better receiver only managed to acquire the signal successfully on 58% ($\pm 9\%$) of the tests. The use of notch filters gave only a marginally higher success rate; 40% as opposed to 39% without notches, etc. Therefore, it can be implied that interference from CKN is far less troublesome in Area #2 than in Area #1.

The field strengths observed from the three transmitters for this area were: -

Table 7

Field Strengths, Area #2

| | |
|------------|-------------------------------|
| Master | 450 to 1000 microvolts/metre |
| Shoal Cove | 40 to 150 microvolts/metre |
| George | 2500 to 4400 microvolts/metre |

The field strength for Shoal Cove approaches the level needed for reliable use in this area.

Central B.C. Coast

The results of the test for areas north of Tofino (north of Latitude 49° N) and south of Browning Entrance in Hecate Strait (south of Latitude 54° N) or south of Tasu off the west coast of the Queen Charlotte Islands (Latitude 53° N) were more successful than the results at the inshore extremes of the chain. In Areas 3, 4, 5, 6, 7, 10 and 12, between 70 and 90% of the tests were a success. The use of notch filters made little difference to the level of success in the cycle identification tests. The success rate of TD-X and TD-Y varies slightly with the distance from the transmitter in central coverage of the chain.

Offshore in Area #12, where the *Parizeau* ran out toward the two hundred mile limit, the tests were reasonably successful. The differences within the factors measured in the experiment were negligible in this area. The

field strengths of the signals at Lat. 50° N, 135° W, were: -

Table 8

Field Strengths Offshore

| | |
|------------|-----------------------|
| Master | 500 microvolts/metre |
| Shoal Cove | 1700 microvolts/metre |
| George | 800 microvolts/metre |

Time did not allow the collection of data in Area #11, offshore from the northern B.C. coast.

Northern B.C. Coast

The northern extremity of the coverage area (Areas 8 and 9) showed a mirror image of the problems encountered with cycle identification at Juan de Fuca entrance. In Dixon Entrance the overall probability of making a successful acquisition of the chain was 44%. Of course, the majority of errors in cycle identification can be attributed to the low signal strength on the George transmission. TD-X was acquired successfully almost 100% of the time. Off the northwest coast of the Queen Charlotte Islands (Area #9) the successful acquisition rate was 59%. Again, the errors are attributable to the weakness of the transmission from George. The use of notch filters in these two areas seems to make little or no difference to the success or failure of an acquisition attempt. Typical field strengths (microvolts/metre) from the three transmitters for these areas are: -

Table 9

Field Strengths, Dixon Entrance

| | <u>Area #8</u> | <u>Area #9</u> |
|------------|----------------|----------------|
| Master | 500 | 450 |
| Shoal Cove | 17000 | 9000 |
| George | 22 | 120 |

In Dixon Entrance, after the initial acquisition test had been made, and had been judged to be a failure, the receivers were made to track on what was thought to be third cycle. Generally, two receivers tracked the signal accurately; but it should be noted that on one occasion when the ship was making a 90° turn the receivers skipped a cycle. Similar tracking tests were made in Juan de Fuca Strait; here the LC 204 would track 3rd cycle ground wave, but the DL 91 immediately moved onto skywave.

Another passage was made through Dixon Entrance in July 1977. This time an attempt was made to use the Gulf of Alaska Chain. The commercial receiver in use, an Internav LC 204 could not acquire the master transmission of this chain until the ship (C.S.S. *Pandora II*) was well clear of the land. Similarly the Austron 5000 monitor system tracked skywave

from the master at Tok, Alaska, as the ground wave was too weak to be identified. The weakness of the ground wave only became apparent when the ship was well clear of the land. As a ship steams west out of Dixon Entrance the landpath to Tok decreases rapidly.

Other Factors

Just as overlap of Loran-C coverage exists in northern B.C. waters with the Gulf of Alaska Chain; overlaps also occur with the U.S. West Coast Chain in southwestern B.C. The series of tests in *Vector* were made to see if the U.S. West Coast Chain might provide better coverage than the West Canadian Chain. The first thing to note when considering this substitution is that the geometric error of position is five times greater for the U.S. Chain than for the Canadian Chain, in this area. The cycle identification tests in *Vector* had the following results: -

Table 10
Chain Comparison

| | <u>U.S.</u> | <u>Canadian</u> |
|-------------------------|-------------|-----------------|
| Number of Tests | 51 | 53 |
| Successes | 24 | 24 |
| Failures | 27 | 29 |
| Proportion of Successes | 0.47 | 0.45 |
| Std. Dev. of Proportion | ±0.07 | ±0.07 |

Noting the standard deviation of the proportions, it cannot be said with any high degree of confidence that these data show that the U.S. and Canadian Chains have different cycle identification capabilities.

Table 11
Transmission Pair Comparison

| | <u>U.S.</u> | | <u>Canadian</u> | |
|-------------------------|-------------|-------------|-----------------|-------------|
| | <u>TD-W</u> | <u>TD-X</u> | <u>TD-X</u> | <u>TD-Y</u> |
| Number of Tests | 51 | 51 | 53 | 53 |
| Successes | 36 | 32 | 24 | 53 |
| Failures | 15 | 19 | 29 | 0 |
| Proportion of Successes | 0.71 | 0.63 | 0.45 | 1 |
| Std. Dev. of Proportion | ±0.06 | ±0.07 | ±0.07 | 0 |

Again, the data emphasizes the weakness of the Shoal Cove transmissions. It also implies that the Fallon and Middleton transmissions may not be reliably acquired in the Strait of Georgia. The field strengths and signal to noise ratios, associated with the above data are given in Appendix 3, together with a more detailed breakdown of the cycle identification data.

The time taken for a receiver to indicate (i.e. turn its indicator lights out) that it had successfully acquired both T.D.'s correctly is shown in Figure 5. Although there is a small degree of correlation between time taken and failure or success in acquisition, this is not appreciable. Information from the receiver manufacturers suggests that time taken to acquire a signal is a function of ambient noise. Also a receiver will just as quickly acquire skywave if there is no groundwave to be seen. The time taken to acquire a signal whether right or wrong, does not appear to vary with area (see Figure 6). Generally it can be stated that it will take between 5 and 10 minutes to make an acquisition, and if the receiver takes 15 minutes or over, it is more likely to be wrong than right.

The size of the error caused by an incorrect acquisition is of great interest to the user. Large errors are, in many cases, easily detectable. Figure 7 shows the distribution of cycle acquisition errors in Areas #1, 2 and 8. When errors occur they tend to be large. Thirty percent of the tests acquired the signal 5 or more cycles high. A very high proportion of that thirty percent is in the "or more" category. This implies that the receiver in those cases was not tracking any reliable signal. Frequently, a receiver will show 3 cycles high when it makes an incorrect acquisition and this should be easily detectable given a good dead reckoning position or visual check.

Conclusions - from Tests made in the Spring of 1977

A navigator, turning on a Loran-C receiver at the extremities of the coverage area of the West Canadian Chain, has an unsatisfactorily low probability of correctly acquiring the transmission from the farthest secondary station. These present extremities of the coverage, Juan de Fuca Strait and Dixon Entrance, are well within the original design coverage. Although these tests were made prior to the commissioning of the chain they do aid in identifying areas of poor coverage, and appropriate warnings have been placed on latticed charts.

U.S.C.G. TESTS - November 1977

The text of the U.S.C.G. report is given in Appendix 4. Their tests were made in Puget Sound, Georgia Strait, Juan de Fuca Strait and off the S.W. coast of Vancouver Island. For comparison with tests made in *Vector* the following data, collected in Georgia Strait, is tabulated here.

Table 12

U.S.C.G. Tests

U.S. West Coast Chain - Georgia Strait

| <u>Receiver</u> | <u>Number of Tests</u> | <u>Successes</u> | <u>Proportion</u> | <u>Std. Deviation</u> |
|-----------------|------------------------|------------------|-------------------|-----------------------|
| LC 204 | 76 | 73 | 0.96 | ±0.02 |
| ML 200 | 76 | 44 | 0.58 | ±0.05 |
| TD 708 | 76 | 33 | 0.43 | ±0.05 |
| All Receivers | 228 | 150 | 0.66 | ±0.03 |

The tests made in *Vector*, in the same area, before commissioning, achieved only a 47% success rate for the "average" receiver as opposed to 66% in the U.S.C.G. tests. In *Vector* the LC 204, which is the only receiver in common between the two tests, gave 58% (±10%) success rate.

The U.S.C.G. tests off Vancouver Island also produced much better results than the earlier C.H.S. tests. See Conclusion #3, page 39. West of Cape Beale, a 100% success in acquiring signals was achieved with all receivers. East of Cape Beale at the approaches to Juan de Fuca Strait only the Internav LC 204 produced any useful results. It had a success rate of 78% (±15%). The other three receivers did not correctly acquire the signal in any one of the nine trials.

The U.S.C.G. officer making this report recommended that in view of the poor publicity and legal aspects of the Loran-C chain accuracy in the area west of Cape Beale the Canadian Government be advised to conduct another survey.

CYCLE IDENTIFICATION TESTS, Autumn 1978

Further cycle identification tests were made in C.S.S. *Parizeau* (Capt. A. Chamberlain) at the entrance to Juan de Fuca Strait in November, 1978. Again, local manufacturers' representatives made several receivers available and over 800 individual cycle selection tests were made. The experiment was designed to describe the cycle identification capabilities of the two Loran-C Chains available in this important area. Such factors as:

- 1) whether the ship was east or west of Cape Beale,
- 2) weather effect,
- 3) sunrise (sunset) effect,
- 4) operator influence;
- 5) previous data, and
- 6) type of receiver,

were considered in the data collection and analysis.

Object: To define from the users' viewpoint, Loran-C cycle identification capabilities at the approaches to Juan de Fuca Strait. These tests were not receiver evaluations.

Equipment: Five commercial Loran-C receivers were used to collect cycle selection data. These receivers, an Internav LC 204, an Internav LC 123, a Decca DL 91, an S.R.D. (c) and a Texas Instruments 9000A, were installed in *Parizeau's* main laboratory. A Meico CDX II Loran-C receiver was put on the ship's bridge for evaluation purposes. The availability of the LC 204 and DL 91 allowed comparison with the previous experiment in *Parizeau*. The only receiver used in common with the U.S.C.G. trials was the LC 204. The manufacturers' specifications for all the receivers used in the C.H.S. tests are given in Appendix I.

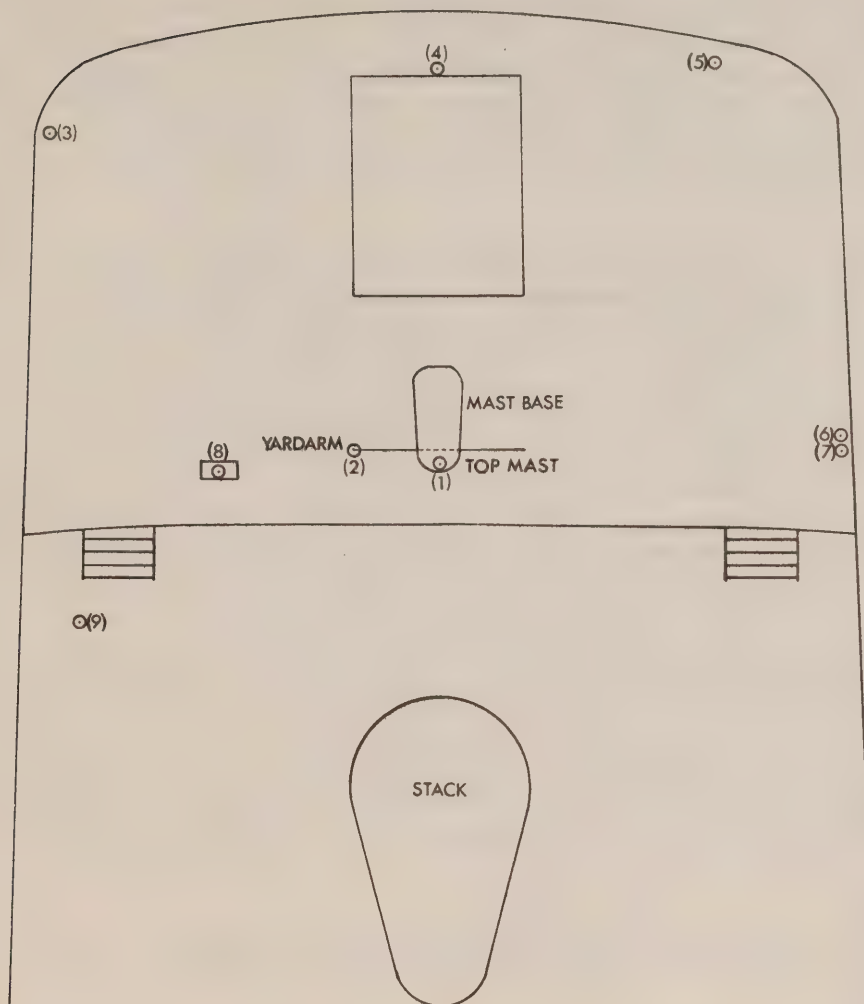
An Austron 5000 Loran-C monitor system was used to continuously track the Loran-C signals for both the Canadian and U.S. West Coast Chains. Receiver gain, T.O.A. variance and cycle number were logged together with position line information. The oscilloscope display on the Austron receiver was monitored continuously to ensure proper third cycle tracking of all signals. During the period of the tests, the Austron receiver failed to track correctly the Shoal Cove (5990-X) transmission on four occasions, either at sunset or sunrise or during rainy weather. Improper tracking occurred once with the Middleton (9940-X) transmission. Thus a total of ten tests had to be disregarded when the Austron did not track correctly, or when the cycle number exceeded the limits 2.60 to 3.40.

Frequent checks were made on the validity of the Austron position line data with the Satnav fixes from an integrated navigation system. These comparisons were also to check the Loran-C lattice on Chart 3652.

The antennae for the DL 91, S.R.D.(c) and TI 9000A Loran-C receivers were placed above the ship's bridge, allowing as much clearance as possible from obstructions. The antennae for the Internav receivers were permanently installed on the ship's yardarm and provided signals to both the LC 204 and the LC 123. Therefore the two Internav receivers had the advantage of a high antenna, clear of obstructions. The antenna from the Austron 5000 was

CSS Parizeau Loran-C Antenna Locations

Scale 1" = 10'



LEGEND

ANTENNAE

- (1) Austron 5000
- (2) Internav LC 204, and LC 123
- (3) Decca DL 91
- (4) Meico CDX II
- (5) SRD (C)
- (6) Texas Instruments 9000A
- (7) Radio Telephone 2-3MHz xmtr
- (8) trunk for 4 span horizontal 25 MHz to 400 kHz xmtr
- (9) 2620 to 16 MHz xmtr

NOTE Average height above water for the antenna bases is 34 feet.

Figure 9

placed on the ship's topmast, clear of all obstructions except for the ship's satellite antenna (see Figure 9).

Method: Each set of cycle identification tests was made over a half hour interval. The five receivers were turned on simultaneously and set to their appropriate acquisition functions. When the receivers indicated they had acquired the signal, the T.D.'s displayed were noted and compared to the T.D.'s given by the Austron monitor system. If a receiver did not indicate that it had acquired the signal within 20 minutes, the test, for that receiver, was treated as a failure. The times of the start and end of the test for each receiver were noted.

At the start of the last ten minutes of the half hourly test periods each receiver was set on the correct T.D.'s and put into tracking (normal) mode. If the receiver stayed locked on to both of the correct T.D.'s for the remainder of the period, this test of the receiver's tracking ability was considered to have been successful. Although the time available for the tracking test was limited, this test gives a good indication of the systems' ability to provide reliable position information given a good start (e.g. from a radar fix). Generally, a Loran-C receiver will track a signal correctly under much poorer conditions than it will acquire the signals. Thus if it can be settled down on third cycle within ten minutes it will probably be able to hold the signals until there is a change in reception conditions.

Tests were made alternately for the West Canadian Chain and for the U.S. West Coast Chain. The observations were made on three stations at the approaches to Juan de Fuca Strait, within Area #2 shown on Figure 10. The first station occupied was on Swiftsure Bank, east of Cape Beale. Measurements were made at two stations west of Cape Beale, one of these offshore on La Pérouse Bank and the other inshore off Barkley Sound. The stations were occupied over the sunrise or sunset period in the following order.

Table 13
Times and Places of Autumn, 1978 Tests

| <u>Number of Tests</u> (5990) | <u>Station</u> | <u>Local Time</u> | <u>Day</u> |
|----------------------------------|-----------------------|-------------------|------------|
| 7 | Swiftsure Bank (1) | 0400-1100 | 326 |
| 5 | Off Barkley Sound (2) | 1100-1800 | 326 |
| 21 | La Pérouse Bank (3) | 1800-1400 | 326/327 |
| 6 | Swiftsure Bank | 1400-2000 | 327 |
| 17 | La Pérouse Bank | 2000-1500 | 327/328 |
| 6 | Swiftsure Bank | 1500-2100 | 328 |
| 11 | Off Barkley Sound | 2100-1000 | 328/329 |
| 5 | La Pérouse Bank | 1000-1500 | 329 |

A few tests were also made off Cape Alava, but the data from these have not been included in the analysis as they were outside of Area #2, that was

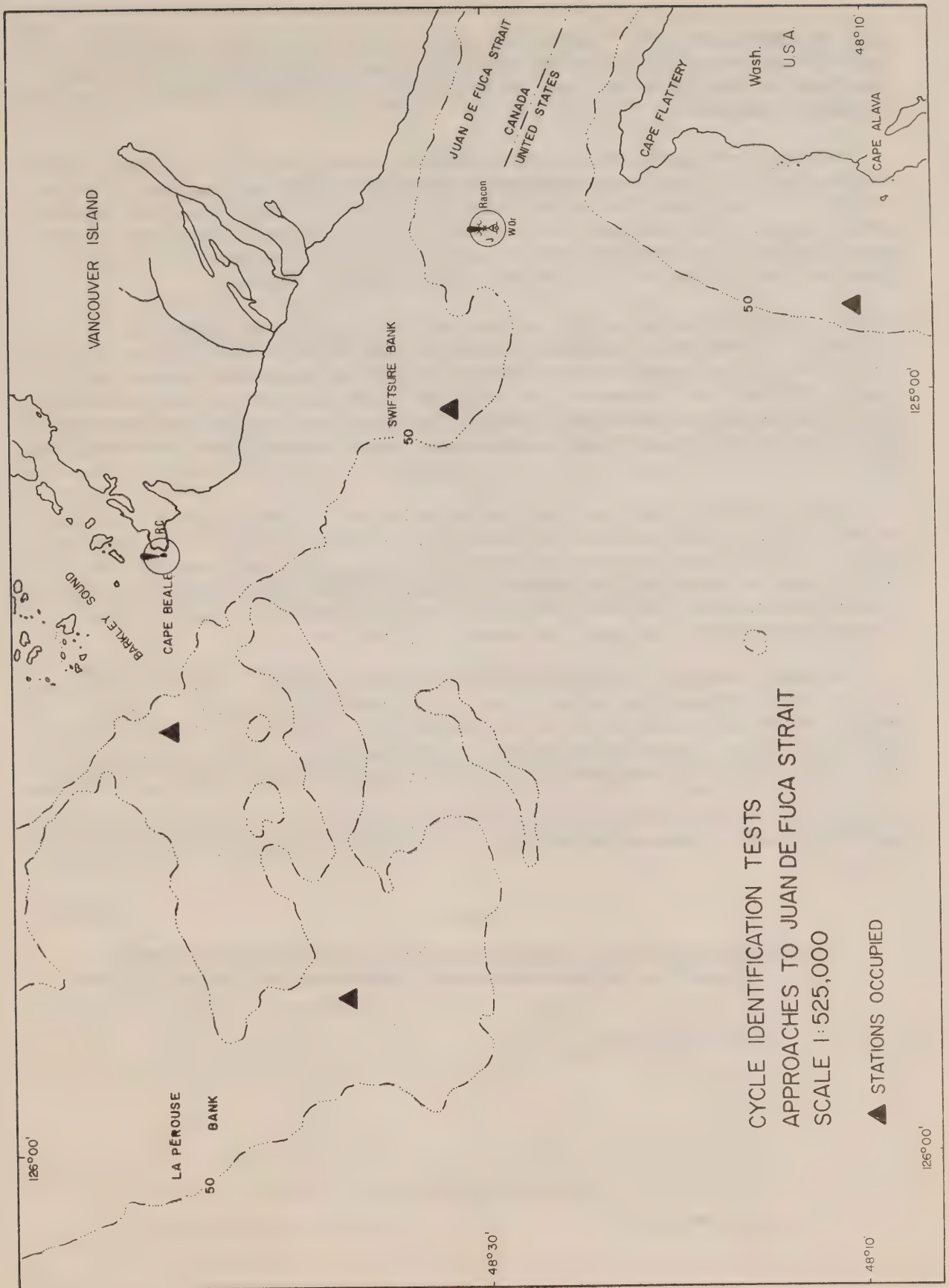


Figure 10

used in Spring of 1977. As the operation was not entirely concerned with cycle identification tests, far more tests were made west of Cape Beale than east of it. The ship was on station, and drifting during the sunrise or sunset period.

All the equipment functioned reasonably well during the tests. Overheating appeared to cause problems in some receivers such as the Internav LC 204. It was found to be necessary to stop the tests for about an hour every day to allow the receivers to cool down. Position line and signal characteristic information were logged at 10-minute intervals on a data terminal associated with the Austron 5000 monitor system.

Data: The observed data for the autumn, 1978 tests are tabulated in Appendix 5. The cycle numbers, logged on the Austron 5000 at the time of each test are included in the Tabulation. Tests where the Austron cycle number did not fall between 2.60 and 3.40 were not used in the data analysis. Histograms were plotted showing the distribution of time to acquire the signals and the distribution of whole cycle errors (see Figures 11 and 13).

Data analysis started with the calculation of the proportion of successful signal acquisitions for each chain - 5990 and 9940, for each T.D. pair in the chains, for tracking ability using each chain and for the proportion of potentially dangerous acquisitions. These main data sets were further partitioned to describe the effects of weather - rain or fine, sunset or sunrise, operator and area of operation.

Another feature that was isolated from the observed data was the number of acquisitions that were 10 or 20 microseconds in error. Such acquisitions were considered to be potentially hazardous; since errors of less than 3 n.m. could be confusing to the navigator when erroneous. Loran-C position is compared to a position derived from another system.

Discussion: The acquisition tests at the approaches to Juan de Fuca Strait were made over a period of four days. The overall results are given in Table 14.

Table 14

Summary of Overall Acquisition Test Results, Autumn 1978
(Std. Dev. of Proportions are given in parenthesis.)

| | 5990 | 9940 |
|----------------------------------|------------|------------|
| Number of Tests | 350 | 365 |
| Successes | 171 | 195 |
| Failures | 179 | 170 |
| Proportion of Successes | 0.49 (.03) | 0.53 (.03) |
| Proportion Potentially Hazardous | 0.17 (.02) | 0.22 (.02) |
| Best Receiver | 0.70 (.06) | 0.88 (.04) |

Now this first look at the acquisition test data is not very encouraging, so it is necessary to consider the various effects in the tests. Table 15 shows results for each time difference pair in the two chains. The sizes of the acquisition errors for Shoal Cove are shown in Figure 11.

Table 15
Time Difference Test Results

| | <u>5990</u> | | <u>9940</u> | |
|------------------------------|-------------|------|-------------|------|
| | X | Y | W | X |
| Number of Tests | 350 | 350 | 365 | 365 |
| Proportion of Successes | 0.52 | 0.90 | 0.79 | 0.57 |
| Std. Deviation of Proportion | 0.03 | 0.02 | 0.02 | 0.03 |

The above table of course indicates that the problem of cycle identification in this area is still that of acquiring the signal from the farthest transmitters. The cycle numbers, averaged for all the tests, are given in Table 16.

Table 16
Cycle Numbers, Average for All Tests
(Sample Std. Dev. given in parenthesis)

| | <u>M</u> | <u>X(or W)</u> | <u>Y (or X)</u> |
|------------------------|-------------|----------------|-----------------|
| West Canadian (5990) | 2.97 (0.05) | 3.04 (0.19) | 2.94 (0.06) |
| U.S. West Coast (9440) | 3.00 (0.08) | 3.00 (0.06) | 3.15 (0.11) |

It is worthwhile noting that the standard deviation of the Shoal Cove cycle number is much larger than other standard deviations. The Austron 5000 receiver had not been calibrated. Therefore these cycle numbers do not give an absolute measure of envelope to cycle difference, but do show the changes experienced with varying conditions.

Receivers

Another aspect to consider in analyzing the overall test results is the performance of the individual receivers used in the tests. The results for both the acquisition and the tracking tests for the five receivers, for both chains are given in Table 17. The proportion of successful acquisition and tracking tests are tabulated, together with the standard deviation of the proportions in parenthesis.

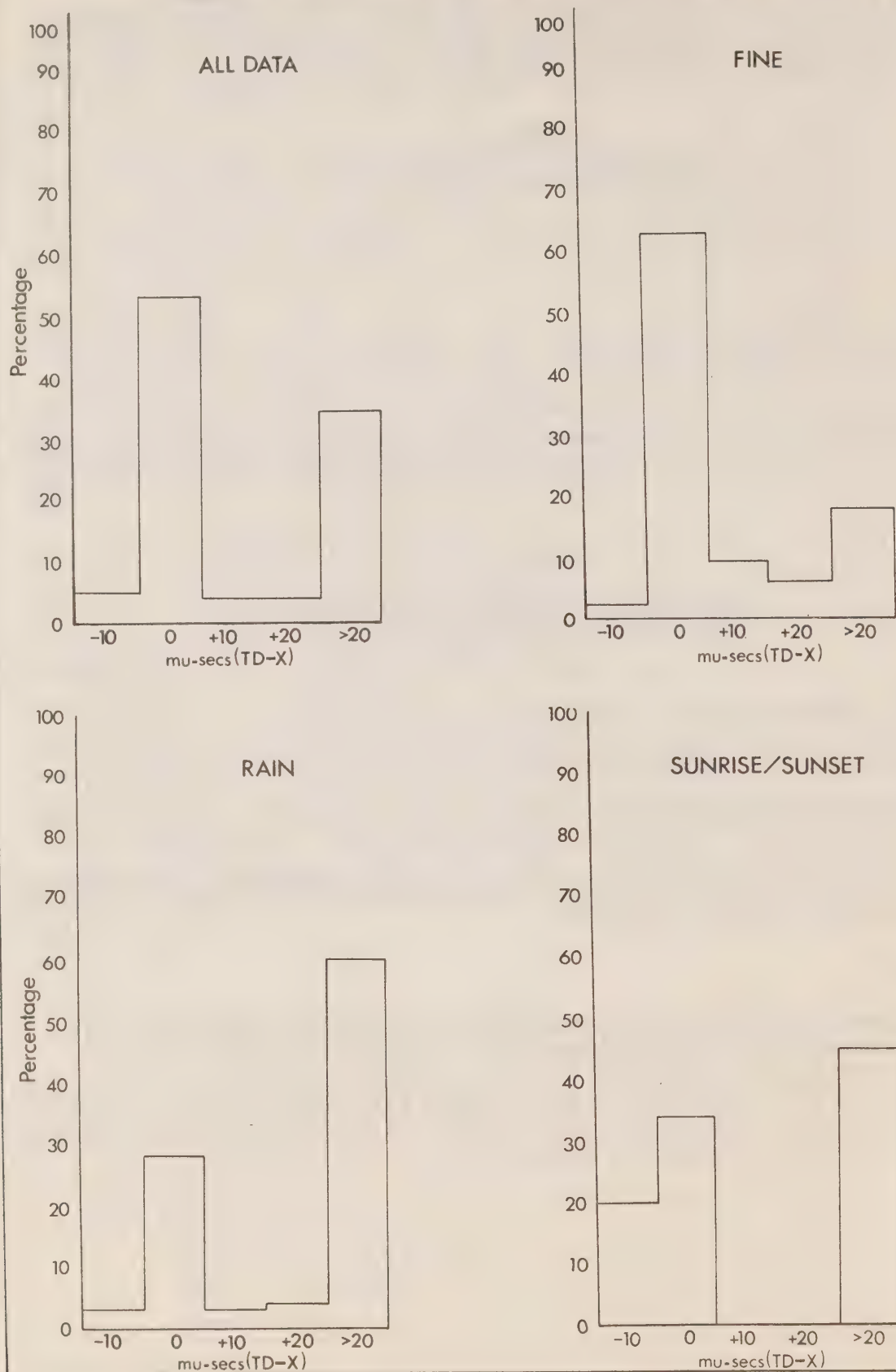
RELATIVE FREQUENCY OF ACQUISITION ERRORS 5990X

Figure 11

Table 17
Receiver Performance Results, Autumn 1978
 (Proportion of Successes)

| | <u>Acquisition</u> | | <u>Tracking</u> | |
|-----------------|--------------------|-------------|-----------------|-------------|
| | <u>5990</u> | <u>9940</u> | <u>5990</u> | <u>9440</u> |
| Internav LC 204 | 0.56 (.06) | 0.66 (.06) | 0.83 (.05) | 0.78 (.05) |
| Internav LC 123 | 0.70 (.06) | 0.88 (.04) | 0.94 (.03) | 0.97 (.02) |
| Decca DL 91 | 0.41 (.06) | 0.38 (.06) | 0.56 (.06) | 0.45 (.06) |
| S.R.D. (c) | 0.50 (.06) | 0.62 (.06) | 0.76 (.05) | 0.77 (.05) |
| T.I. 9000 A | 0.27 (.05) | 0.14 (.04) | 0.50 (.06) | 0.33 (.06) |

Thus there is a wide variation in performance for the receivers used. The poor showing of the Decca, in the tracking tests may be explained by operator or equipment problems when setting the correct time differences in the displays. The Decca was fitted with a pear shaped copper antenna that is claimed to work well under poor reception conditions. But data indicates that the DL 91's performance still declined markedly in rainy weather. No explanation for the Texas Instruments 9000 A receiver's poor performance can be offered except that its antenna was adjacent to another communication antenna. When trying to acquire the U.S. West Coast Chain this receiver would frequently select the TD-Y (Fallon-Searchlight) pair, presumably using a strong skywave signal from Searchlight. There were some differences to be noted in the performance of the receivers between the tests in the spring of 1977 and those in the fall of 1978, where the Decca DL 91 and the Internav LC 204 were both used in both sets of tests.

Table 18
Receiver Performance, 1977 and 1978

| | <u>DL 91</u> | | <u>LC 204</u> | |
|-------------------------|--------------|-------|---------------|-------|
| | 1977 | 1978 | 1977 | 1978 |
| Number of Tests | 19 | 70 | 19 | 70 |
| Successes | 4 | 31 | 11 | 40 |
| Failures | 15 | 39 | 8 | 30 |
| Proportion of Successes | 0.21 | 0.41 | 0.58 | 0.56 |
| Std. Dev. of Proportion | ±0.09 | ±0.06 | ±0.11 | ±0.06 |

The improved acquisition capabilities of the DL 91 are apparent. There is no significant change in the performance of the LC 204.

Operators

Another influence on the experiment was the varying ability of the three operators. The data in Table 19 gives an indication of variations of operator ability over a twenty-four hour period.

Table 19

Operator's Influence

(Std. Dev. of Proportions given in Parenthesis.)

| | <u>Operators</u> | | |
|------------------------|------------------|------------|------------|
| | 1 | 2 | 3 |
| Number of Tests | 40 | 65 | 70 |
| Successful Acquisition | 0.53 (.08) | 0.51 (.06) | 0.47 (.06) |
| Successful Tracking | 0.83 (.06) | 0.72 (.06) | 0.69 (.06) |

There is little variation between operators in making successful signal acquisitions as this is a very simple process from the operator's viewpoint. Some variation can be detected in successfully tracking the Loran-C signals, as this process requires a little more operator interaction with the receiver.

Analysis by Area

Most of the tests were made at (and around) three positions within Area #2, on Swiftsure Bank, off Barkley Sound and on La Pérouse Bank (Big Bank), (see Figure 10). A summary of the acquisition data at the three stations is given in Table 20.

Table 20
Acquisition Test Results for the Stations Occupied

| | <u>Swiftsure Bank</u> | <u>Barkley Sound</u> | <u>La Pérouse Bank</u> |
|-------------------------------------|------------------------------|--------------------------|----------------------------|
| | <u>West Canadian Chain</u> | | |
| Number of Tests | 75 | 80 | 204 |
| Successes | 31 | 40 | 107 |
| Failures | 44 | 40 | 97 |
| Proportion of Successes | 0.41 | 0.50 | 0.52 |
| Std. Dev. of Proportions | ± 0.06 | ± 0.06 | ± 0.03 |
| Proportion potentially hazardous | 0.07 | 0.18 | 0.18 |
| Std. Dev. of Proportion | ± 0.03 | ± 0.04 | ± 0.03 |
| | <u>U.S. West Coast Chain</u> | | |
| Number of Tests | 95 | 70 | 210 |
| Successes | 51 | 40 | 102 |
| Failures | 44 | 30 | 108 |
| Proportion of Successes | 0.54 | 0.57 | 0.49 |
| Std. Dev. of Proportion | ± 0.05 | ± 0.06 | ± 0.03 |
| Proportion Potentially hazardous | 0.23 | 0.13 | 0.23 |
| Std. Dev. of Proportion | ± 0.04 | ± 0.04 | ± 0.03 |

These results are disappointing, especially those for the U.S. West Coast Chain. But three points are noteworthy.

1. The difference in performance of the West Canadian Chain east and west of Cape Beale.
2. The higher proportion of potentially hazardous acquisitions west of Cape Beale. It is assumed that east of Cape Beale skywave is usually acquired and gross acquisition errors occur.
3. It is not possible to identify any onshore-offshore effect as the results of tests on La Pérouse Bank and off Barkley Sound are similar.

Table 21 compares the data sets obtained west and east of Cape Beale for the West Canadian Chain. See also Figure 12.

Table 21

Proportion of Successful Tests - West and East of Cape Beale (5990)

(Std. Dev. of Proportions are given in Parenthesis.)

| | <u>West</u> | <u>East</u> |
|-----------------------------|-------------|-------------|
| Number of Tests | 255 | 75 |
| Successful Acquisitions | 0.51 (.03) | 0.41 (.06) |
| Successful Tracking | 0.68 (.03) | 0.72 (.05) |
| Potentially Hazardous | 0.16 (.02) | 0.07 (.03) |
| Best Receiver (Acquisition) | 0.80 (.06) | 0.53 (.13) |
| Best Receiver (Tracking) | 0.98 (.02) | 0.80 (.11) |

Twilight Effect (Sunset/Sunrise)

Analysis by area shows some interesting features but it does not account for the generally poor performance during the 1978 tests. These tests were designed so that the ship was on station during the sunset or sunrise period. The data available, for the West Canadian Chain - at sunset or sunrise is tabulated in Table 22.

Table 22

Proportion of Successful Tests - Sunset or Sunrise

(Std. Dev. of Proportions are given in Parenthesis.)

| | <u>5990</u> | | <u>9940</u> | |
|-------------------------|--------------------|---------------------|--------------------|---------------------|
| | <u>Sunset/rise</u> | <u>Average Data</u> | <u>Sunset/rise</u> | <u>Average Data</u> |
| Number of Tests | 35 | 350 | 35 | 365 |
| Successful Acquisitions | 0.31 (.08) | 0.49 (.03) | 0.54 (.09) | 0.53 (.03) |
| Successful Tracking | 0.66 (.08) | 0.72 (.02) | 0.60 (.08) | 0.66 (.02) |
| Potentially Hazardous | 0.20 (.07) | 0.17 (.02) | 0.11 (.05) | 0.22 (.02) |
| X-Acquisitions only | 0.34 (.08) | 0.52 (.03) | (W)0.83 (.06) | 0.79 (.02) |
| Y-Acquisitions only | 0.94 (.14) | 0.90 (.02) | (X)0.57 (.08) | 0.57 (.03) |
| Best Receiver (Acq.) | 0.43 (.20) | 0.70 (.06) | 0.86 (.14) | 0.88 (.04) |

Now these statistics indicate a definite deterioration of operational capabilities for the Canadian Chain when compared to averaged data given previously in Tables 14, 15 and 20. The acquisition rate drops for the West Canadian Chain from 49% for the average over 4 days to 31% at sunset/sunrise. Isolating the TD-X pair, the rate of successful acquisition drops from 52% for the average over 4 days to 34% at sunset or sunrise. The Austron cycle number for the X-secondary increases appreciably during the sunset or sunrise periods. The average cycle number for the X-secondary of the Canadian Chain is 3.04, but at sunset or sunrise this number rises to 3.10. So at sunset or sunrise, when there is usually a lot of skywave

activity the shape of an already weak pulse becomes distorted. When the signal is strong the cycle number does not change very much at sunset or sunrise. The Y-secondary cycle number changes only from 2.94 for average conditions to 2.95 during sunset or sunrise. These and additional data are shown in Figure 12. Now the U.S. Chain shows hardly any change in performance when comparing the tests made during sunset or sunrise with the average of all the data.

Thus it appears that Shoal Cove reception is the culprit. And it can be inferred that when reception of a station is already marginal, acquisition ability is even further impaired at dawn or dusk. When Loran-C reception conditions are adequate, then there is no difference in acquisition ability at sunset or sunrise when compared to the rest of the day.

Precipitation Static

Now the weather also affects Loran-C cycle identification. It was fortunate from this viewpoint that during the four days of measurements made at the entrance to Juan de Fuca Strait there was one complete rainy day and one complete fine day. The measurements made on these two days in the La Pérouse Bank area using the Canadian Chain are tabulated in Table 23.

Table 23

Proportion of Successful Tests - Rain or Fine
(Std. Dev. of Proportions are given in Parenthesis.)

| | <u>5990 - La Perouse Bank</u> | | |
|-------------------------|-------------------------------|-----------------|------------------|
| | <u>Average Day</u> | <u>Fine Day</u> | <u>Rainy Day</u> |
| Number of Tests | 205 | 65 | 65 |
| Successful Acquisitions | 0.52 (.03) | 0.57 (.05) | 0.26 (.05) |
| Successful Tracking | 0.68 (.03) | 0.75 (.05) | 0.57 (.06) |
| Potentially Hazardous | 0.18 (.03) | 0.22 (.05) | 0.17 (.15) |
| X-Acquisitions Only | 0.56 (.03) | 0.60 (.06) | 0.29 (.06) |
| Y-Acquisitions Only | 0.90 (.03) | 0.88 (.04) | 0.86 (.04) |
| Best Receiver (Acq.) | 0.80 (.06) | 0.77 (.12) | 0.62 (.14) |

The cycle numbers for both chains observed under different weather conditions are given in Table 24.

Table 24

Cycle Numbers - Rainy, Fine, Sunset or Sunrise

| | <u>5990</u> | | | <u>9940</u> | | |
|----------------|-------------|------|------|-------------|------|------|
| | M | X | y | M | W | X |
| Average | 2.97 | 3.04 | 2.94 | 3.00 | 3.00 | 3.15 |
| Fine | 2.98 | 2.94 | 2.94 | 3.00 | 3.03 | 3.15 |
| Rainy | 2.96 | 3.12 | 2.93 | 3.00 | 2.98 | 3.18 |
| Sunset/Sunrise | 2.98 | 3.10 | 2.95 | 2.98 | 3.00 | 3.14 |

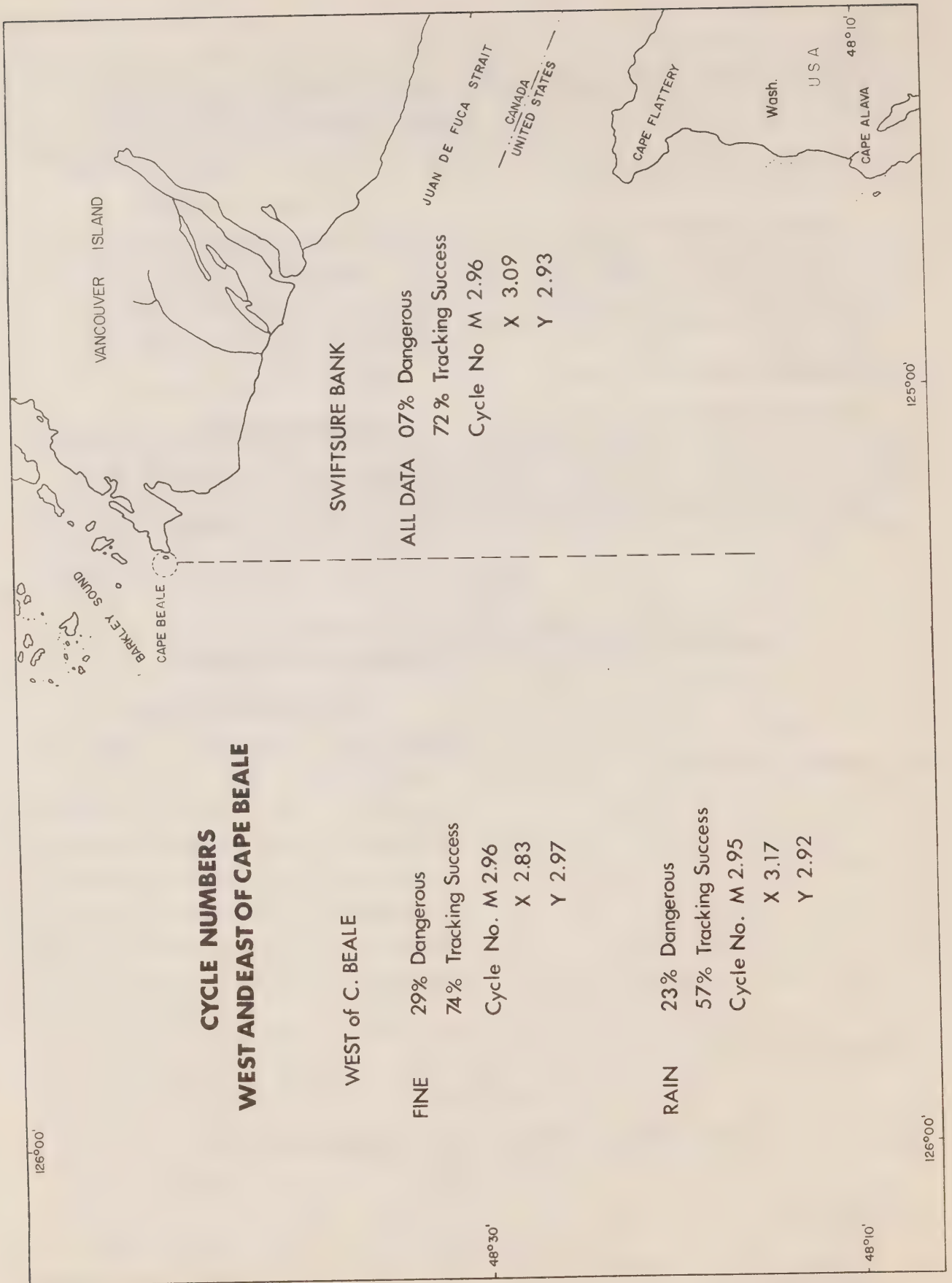


Figure 12

The only appreciable change in cycle number for six stations monitored is in the Shoal Cove transmission where the number has a range of 0.18. The weather effect data for the U.S. West Coast Chain is given in Table 25. For this chain the weather effect is not as marked as for the Canadian Chain, but cycle acquisition characteristics still deteriorate in rainy weather.

Table 25

Proportion of Successful Tests - Rainy or Fine

(Std. Dev. of Proportion is given in Parenthesis)

| | <u>9940</u> | | |
|-------------------------|---------------------|-------------|--------------|
| | <u>Average Data</u> | <u>Fine</u> | <u>Rainy</u> |
| Number of Tests | 365 | 100 | 110 |
| Successful Acquisitions | 0.53 (.03) | 0.60 (.05) | 0.47 (.05) |
| Successful Tracking | 0.66 (.02) | 0.67 (.05) | 0.60 (.05) |
| Potentially Hazardous | 0.22 (.02) | 0.17 (.04) | 0.23 (.04) |
| W-Acquisitions Only | 0.79 (.02) | 0.80 (.04) | 0.69 (.04) |
| X-Acquisitions Only | 0.57 (.03) | 0.65 (.05) | 0.56 (.05) |
| Best Receiver (Acq.) | 0.88 (.04) | 1.00 | 0.77 (.09) |

It is well known that precipitation static is not beneficial to low frequency radio wave reception. The figures in Table 23, for the West Canadian Chain amply demonstrate this as the rate of successful signal acquisitions falls from 57% in fine weather to 26% in rain. Once again the reasons for the decrease in successful acquisition can be found in a deterioration of the reception characteristics of the Shoal Cove signal.

Tracking

Table 26 compares the tracking test results under various conditions for both chains.

Table 26

Tracking Tests

(Std. Dev. of Proportions given in Parenthesis.)

| | <u>5990</u> | <u>9940</u> |
|-----------------|-------------|-------------|
| All Data | 0.72 (.02) | 0.66 (.02) |
| Fine Weather | 0.81 (.04) | 0.67 (.05) |
| Rainy Weather | 0.56 (.05) | 0.60 (.05) |
| Sunset/Sunrise | 0.66 (.09) | 0.60 (.08) |
| West Cape Beale | 0.68 (.03) | --- |
| East Cape Beale | 0.72 (.05) | --- |
| Internav 123 | 0.94 (.03) | 0.97 (.02) |
| T.I. 9000 A | 0.50 (.06) | 0.33 (.06) |

Again the tracking tests vary considerably with weather and with receiver type, but very little change is noted between different areas.

Time to Acquire

Time taken to acquire the Loran-C signal by the receivers used is given in Table 27 and this data is also shown in Figure 13 to enable comparison with the 1977 data shown in Figures 5 and 6.

Table 27

Time Taken to Acquire (for Receivers)

| West Canadian Chain | Mean (Minutes) | Std. Dev. of Mean | Proportion of Time to Acquire | | | |
|-----------------------|-------------------|----------------------|-------------------------------|-------|-------|-------|
| | | | <5 m | <10 m | <15 m | >15 m |
| All Receivers | 10.3 | 3.2 | 0.26 | 0.41 | 0.09 | 0.24 |
| Internav 204 | 12.1 | 3.5 | 0.01 | 0.57 | 0.09 | 0.33 |
| Internav 123 | 6.3 | 2.5 | 0.53 | 0.44 | 0.01 | 0.02 |
| Decca DL 91 | 10.5 | 3.2 | 0.10 | 0.61 | 0.07 | 0.22 |
| S.R.D. (C) | 9.3 | 3.1 | 0.44 | 0.21 | 0.14 | 0.21 |
| T.I. 9000A | 13.1 | 3.6 | 0.20 | 0.21 | 0.11 | 0.47 |
| U.S. West Coast Chain | | | | | | |
| All Receivers | 13.4 | 3.7 | 0.07 | 0.32 | 0.22 | 0.39 |
| Internav 204 | 14.6 | 3.8 | 0 | 0.19 | 0.47 | 0.34 |
| Internav 123 | 9.0 | 3.0 | 0.01 | 0.85 | 0.08 | 0.06 |
| Decca D.L. 91 | 14.2 | 3.8 | 0.01 | 0.26 | 0.29 | 0.44 |
| S.R.D. (C) | 11.5 | 3.4 | 0.27 | 0.22 | 0.23 | 0.28 |
| T.I. 9000 A | 18.0 | 4.2 | 0.03 | 0.08 | 0.05 | 0.84 |

RELATIVE FREQUENCY OF TIME TAKEN TO INDICATE ACQUISITION OF SIGNAL

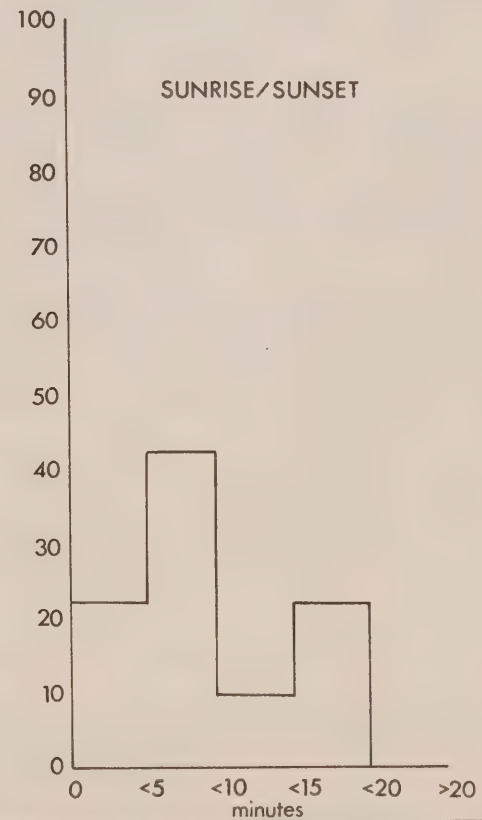
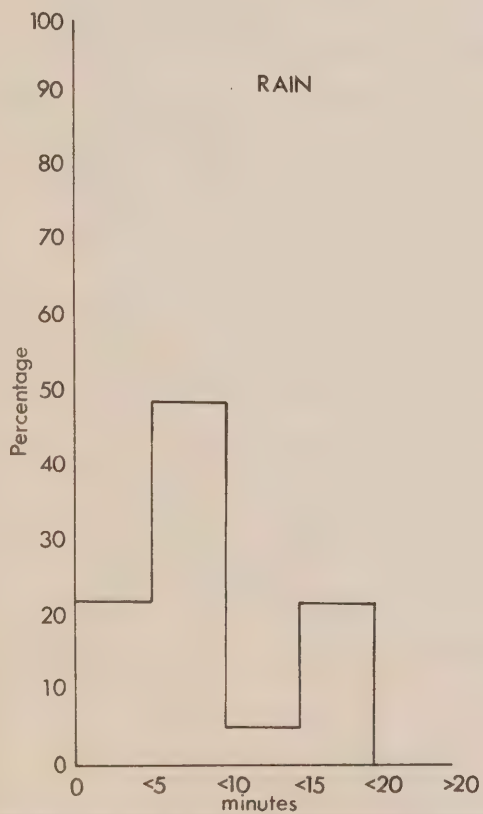
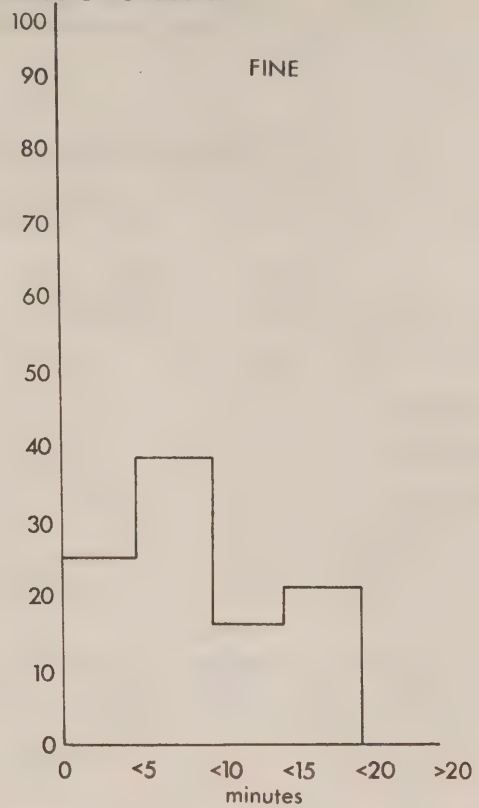
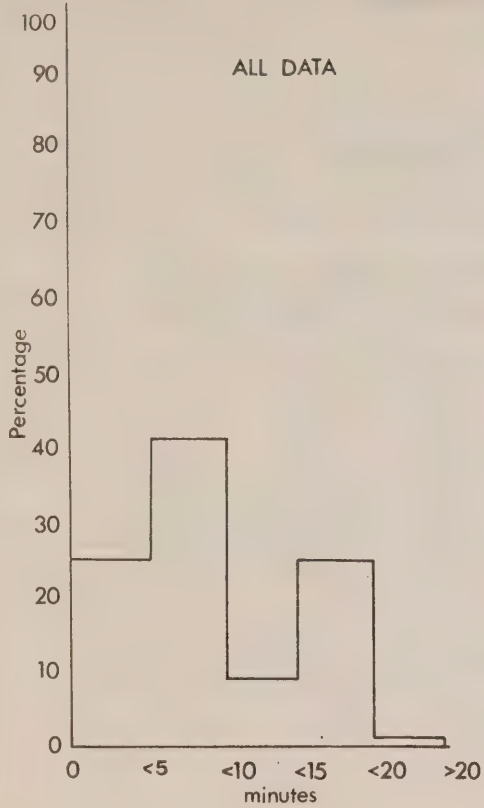


Figure 13

Time taken to acquire the signal for the "average" receiver under varying conditions is given in Table 28.

Table 28
Time Taken to Acquire (Varying Conditions)

| | Canadian Chain | | | | | |
|------------------|----------------|----------------------|-------------------------------|-------|-------|-------|
| | Mean | Std. Dev. of Mean | Proportion of Time To Acquire | | | |
| | | | <5 m | <10 m | <15 m | >15 m |
| All Data | 10.3 | 3.2 | 0.26 | 0.41 | 0.09 | 0.24 |
| Fine Weather | 10.1 | 3.2 | 0.25 | 0.39 | 0.15 | 0.21 |
| Rainy Weather | 9.9 | 3.2 | 0.23 | 0.49 | 0.04 | 0.22 |
| Sunset/Sunrise | 10.3 | 3.2 | 0.23 | 0.43 | 0.11 | 0.23 |
| East of C. Beale | 9.9 | 3.3 | 0.33 | 0.35 | 0.08 | 0.24 |
| West of C. Beale | 10.4 | 3.2 | 0.25 | 0.40 | 0.07 | 0.28 |

Time taken to acquire a Loran-C signal does not change appreciably with the weather or other effects.

CONCLUSIONS

1. The results of the two series of cycle selection tests by the C.H.S. are disappointing. At the approaches to Juan de Fuca Strait, one of the most important areas off Canada's coasts, these tests showed that the Loran-C signal cannot always be accurately acquired. A similar situation exists in Dixon Entrance. Cycle selection capabilities over the rest of the B.C. coast are satisfactory. Comparing the two series of tests made in 1977 and 1978 the rate of successful signal acquisitions increased by about 10%.
2. It is apparent that using cycle selection tests yields a rigorous assessment of a Loran-C chain. This method focusses on only one important aspect of Loran-C usage and it is doubtful if any phase comparison positioning system can produce 100% correct cycle identification.
3. The U.S.C.G. tests gave much better results than the C.H.S. tests. A spectrum analyzer was used by the U.S.C.G. to identify interference and reception problems on the receivers. The C.H.S. did not use a spectrum analyzer during the tests. Therefore it is possible that the installation of receivers, and the use of notch filters in *Parizeau* was not as efficient as in the U.S.C.G. tests. The second series of C.H.S. tests, at the approaches to Juan de Fuca Strait, was made under varying weather conditions over a period of four days (and three nights). The U.S. C.G. do not mention weather or time of day in their tests. The C.H.S. tests were designed to show the cycle identification capabilities under typical operating conditions, which could include imperfect installation and interference rejection, the effects of precipitation static and skywave interference at twilight. It is thought that the C.H.S. tests give a reasonable description of the cycle identification capabilities for the chain under "average" operating conditions.
4. The results of tests made east of Cape Beale indicate that if a receiver is turned on in this area gross errors in the TD-X (Shoal Cove-Williams Lake) position line are likely to occur. These errors are probably attributable to acquiring skywave from Shoal Cove. To the west of Cape Beale, if cycle selection errors are made they are more likely to be of 10 or 20 microseconds in size and may be difficult for the navigator to detect.
5. There is no significant change in the ability of a receiver to track any Loran-C signal anywhere within the test area at the approaches to Juan de Fuca Strait. However, it has been shown that tracking ability does deteriorate in rainy weather when other reception conditions are also poor.
6. The deleterious effect of precipitation static on Loran-C cycle selection has been demonstrated. Similarly, the effect of increasing skywave interference at twilight has been shown. Under both conditions there is a significant decrease in the rate of successful acquisitions for an already weak transmission (such as experienced with the Shoal Cove signal in South Western British Columbia).
7. Although no absolute envelope to cycle difference measurements were made, it can be said that:
 - a. The envelope to cycle difference of the Shoal Cove transmission as measured at the approaches to Juan de Fuca Strait varied by almost ± 2 microseconds over a period of four days.
 - b. Under poor reception conditions the Austron monitor cycle number for the Shoal Cove transmission increased 0.2 (2 microseconds).

- c. The Austron monitor cycle number for the Middleton transmission as received at the approaches to Juan de Fuca Strait is 0.15 (1.5 microseconds) higher than that of the other U.S. West Coast Chain stations.
- 8. The cycle identification tests made in the Spring of 1977 and in the fall of 1978 indicate that the U.S. West Coast Chain provides slightly better cycle identification characteristics than the West Canadian Chain in South Western British Columbia. It is hoped that the new station to be established on Northern Vancouver Island will provide both good geometry and good cycle selection.

References

- 1. Mortimer, A., D.H. Gray and R.M. Eaton, 1978. A Loran-C Calibration, The West Canadian Chain, Offshore Operations and Data Analysis. Pacific Marine Science Report 78-13, Unpublished Manuscript, Institute of Ocean Sciences, Patricia Bay, Sidney, B.C.
- 2. Dugan, R.F., 1977. Trip Report, C.G.C. FIR, 16-19 November, 1977. United States Coast Guard Trip Report, Seattle, Washington.
- 3. 58 pct Success Rate cited for key navigational aid. Vancouver Sun, Wednesday, November 2, 1977, Vancouver, B.C.

APPENDIX 1

Commercial Receiver Specifications

Receiver Specifications

Makers Data

| | Micrologic 200 | Internav 204 | Decca DL 91 | North Star 6000 | S.R.D. C | T.I. 9000A | Internav 123 |
|---|-------------------|-----------------|----------------|--------------------|-------------|---------------|-----------------|
| Dynamic Range | | | | | | | |
| Overall (db) | 110 | 105 | 100 | 110 | NK | 90 | 105 |
| Differential (db) | 86 | NK | 80 | NK | | | |
| Sensitivity (microvolts/metre) | 10 | 2 | 1 | 0.8 | NK | NK | 2 |
| Notch Filters | 4 | 2 | 1 | 2 | 2 | NK | NA |
| Search Time (secs) | 90 | 30 | 90 | NK | 30 | NK | 30 |
| Settling Time (secs) | 800 | 300 | 600 | NK | 240 | 300 | 180 |
| Display Resolution (microsecs, T.D.) | 0.1 | 0.01 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |

NK - Not Known
NA - Not Applicable

APPENDIX 2

Spring 1977 (*Parizeau*)

Cycle Identification Data

Descriptive Statistics

NOTATION:

N = Number of Tests

S = Number of Successes

F = Number of Failures

S/N = P = Proportion of Successes

\sqrt{pq} = Std. Dev. of the Sample

S(S) = Std. Dev. of S (# of Successes)

S(P) = Std. Dev. of P (Proportion of Successes)

$$S(P) = \sqrt{\frac{P(1-P)}{N-1}}$$

Rx (1) = Decca D.L. 91

Rx (2) = Internav LC 204

Cycle Identification Tests
Descriptive Statistics Tabulated by Area

| | <u>N</u> | <u>S</u> | <u>F</u> | <u>S/N</u> | <u>\sqrt{pq}</u> | <u>S(S)</u> | <u>S(P)</u> |
|----------------------------|----------|----------|----------|------------|-------------------------------|-------------|-------------|
| <u>Area #1, Chart 3601</u> | | | | | | | |
| Totals | 89 | 29 | 60 | 0.33 | 0.47 | 4.40 | 0.05 |
| Time differences | | | | | | | |
| Shoal Cove | 89 | 29 | 60 | 0.33 | 0.47 | 4.40 | 0.05 |
| George | 89 | 88 | 1 | 0.99 | 0.11 | 0.99 | 0.01 |
| Receivers | | | | | | | |
| Rx(1) | 43 | 16 | 27 | 0.37 | 0.48 | 3.17 | 0.07 |
| Rx(2) | 46 | 13 | 33 | 0.28 | 0.43 | 3.02 | 0.07 |
| Filters* | | | | | | | |
| Notches In | 30 | 5 | 25 | 0.17 | 0.37 | 2.04 | 0.07 |
| Notches Out | 6 | 0 | 6 | 0.00 | 0.00 | 0.00 | 0.00 |

* excluding data gathered in C.S.S. *Vector*.

Area #2, Chart 3602

| | | | | | | | |
|------------------|----|----|----|------|------|------|------|
| Totals | 38 | 15 | 23 | 0.39 | 0.49 | 3.01 | 0.08 |
| Time differences | | | | | | | |
| Shoal Cove | 38 | 16 | 22 | 0.42 | 0.49 | 3.04 | 0.08 |
| George | 38 | 31 | 7 | 0.82 | 0.39 | 2.39 | 0.06 |
| Receivers | | | | | | | |
| Rx(1) | 19 | 4 | 15 | 0.21 | 0.41 | 1.78 | 0.09 |
| Rx(2) | 19 | 11 | 8 | 0.58 | 0.49 | 2.15 | 0.11 |
| Filters | | | | | | | |
| Notches In | 22 | 9 | 13 | 0.41 | 0.49 | 2.31 | 0.10 |
| Notches Out | 16 | 6 | 10 | 0.38 | 0.48 | 1.94 | 0.12 |

| | <u>N</u> | <u>S</u> | <u>F</u> | <u>S/N</u> | <u>\sqrt{pq}</u> | <u>S(S)</u> | <u>S(P)</u> |
|----------------------------|----------|----------|----------|------------|-------------------------------|-------------|-------------|
| <u>Area #3, Chart 3603</u> | | | | | | | |
| Totals | 54 | 46 | 8 | 0.85 | 0.36 | 2.61 | 0.05 |
| Time differences | | | | | | | |
| Shoal Cove | 54 | 46 | 8 | 0.85 | 0.36 | 2.61 | 0.05 |
| George | 54 | 51 | 3 | 0.94 | 0.23 | 1.68 | 0.03 |
| Receivers | | | | | | | |
| Rx(1) | 27 | 22 | 5 | 0.81 | 0.39 | 2.02 | 0.07 |
| Rx(2) | 27 | 24 | 3 | 0.89 | 0.31 | 1.63 | 0.06 |
| Filters | | | | | | | |
| Notches In | 32 | 27 | 5 | 0.84 | 0.36 | 2.05 | 0.06 |
| Notches Out | 22 | 19 | 3 | 0.86 | 0.34 | 1.61 | 0.07 |
| <u>Area #4, Chart 3604</u> | | | | | | | |
| Totals | 38 | 33 | 5 | 0.87 | 0.34 | 2.08 | 0.05 |
| Time differences | | | | | | | |
| Shoal Cove | 38 | 33 | 5 | 0.87 | 0.34 | 2.08 | 0.05 |
| George | 38 | 35 | 3 | 0.91 | 0.27 | 1.66 | 0.04 |
| Receivers | | | | | | | |
| Rx(1) | 19 | 15 | 4 | 0.79 | 0.41 | 1.78 | 0.09 |
| Rx(2) | 19 | 18 | 1 | 0.95 | 0.22 | 0.97 | 0.05 |
| Filters | | | | | | | |
| Notches In | 30 | 28 | 2 | 0.93 | 0.25 | 1.37 | 0.05 |
| Notches Out | 8 | 5 | 3 | 0.63 | 0.48 | 1.37 | 0.17 |
| <u>Area #5, Chart 3605</u> | | | | | | | |
| Totals | 46 | 32 | 14 | 0.70 | 0.46 | 3.12 | 0.07 |
| Time differences | | | | | | | |
| Shoal Cove | 46 | 42 | 4 | 0.91 | 0.28 | 1.91 | 0.04 |
| George | 46 | 33 | 13 | 0.72 | 0.45 | 3.05 | 0.07 |
| Receivers | | | | | | | |
| Rx(1) | 23 | 15 | 8 | 0.65 | 0.48 | 2.28 | 0.10 |
| Rx(2) | 23 | 17 | 6 | 0.74 | 0.44 | 2.11 | 0.09 |
| Filters | | | | | | | |
| Notches In | 24 | 15 | 9 | 0.63 | 0.48 | 2.37 | 0.10 |
| Notches Out | 22 | 17 | 5 | 0.77 | 0.42 | 1.97 | 0.09 |

| | <u>N</u> | <u>S</u> | <u>F</u> | <u>S/N</u> | <u>\sqrt{pq}</u> | <u>S(S)</u> | <u>S(P)</u> |
|----------------------------|----------|----------|----------|------------|-------------------------------|-------------|-------------|
| <u>Area #6, Chart 3901</u> | | | | | | | |
| Totals | 22 | 17 | 5 | 0.77 | 0.42 | 1.97 | 0.09 |
| Time differences | | | | | | | |
| Shoal Cove | 22 | 19 | 3 | 0.86 | 0.34 | 1.61 | 0.07 |
| George | 22 | 19 | 3 | 0.86 | 0.34 | 1.61 | 0.07 |
| Receivers | | | | | | | |
| Rx(1) | 11 | 9 | 2 | 0.82 | 0.39 | 1.28 | 0.12 |
| Rx(2) | 11 | 8 | 3 | 0.73 | 0.45 | 1.48 | 0.13 |
| Filters | | | | | | | |
| Notches In | 22 | 17 | 5 | 0.77 | 0.42 | 1.97 | 0.09 |
| <u>Area #7, Chart 3902</u> | | | | | | | |
| Totals | 30 | 25 | 5 | 0.83 | 0.37 | 2.04 | 0.07 |
| Time differences | | | | | | | |
| Shoal Cove | 30 | 27 | 3 | 0.90 | 0.30 | 1.64 | 0.05 |
| George | 30 | 25 | 5 | 0.83 | 0.37 | 2.04 | 0.07 |
| Receivers | | | | | | | |
| Rx(1) | 15 | 11 | 4 | 0.73 | 0.44 | 1.71 | 0.11 |
| Rx(2) | 15 | 14 | 1 | 0.93 | 0.25 | 0.97 | 0.06 |
| Filters | | | | | | | |
| Notches In | 20 | 16 | 4 | 0.80 | 0.40 | 1.79 | 0.09 |
| Notches Out | 10 | 9 | 1 | 0.90 | 0.30 | 0.95 | 0.09 |
| <u>Area #8, Chart 3802</u> | | | | | | | |
| Totals | 112 | 49 | 63 | 0.44 | 0.50 | 5.25 | 0.05 |
| Time differences | | | | | | | |
| Shoal Cove | 112 | 107 | 5 | 0.96 | 0.21 | 2.19 | 0.02 |
| George | 112 | 49 | 63 | 0.44 | 0.50 | 5.25 | 0.05 |
| Receivers | | | | | | | |
| Rx(1) | 56 | 10 | 46 | 0.18 | 0.38 | 2.87 | 0.05 |
| Rx(2) | 56 | 39 | 17 | 0.70 | 0.46 | 3.44 | 0.06 |
| Filters | | | | | | | |
| Notches In | 54 | 24 | 30 | 0.44 | 0.50 | 3.65 | 0.07 |
| Notches Out | 58 | 25 | 33 | 0.43 | 0.50 | 3.77 | 0.07 |

| | <u>N</u> | <u>S</u> | <u>F</u> | <u>S/N</u> | <u>\sqrt{pq}</u> | <u>S(S)</u> | <u>S(P)</u> |
|--|----------|----------|----------|------------|-------------------------------|-------------|-------------|
| <u>Area #9, Chart 3801(N)</u> | | | | | | | |
| Totals | 22 | 13 | 9 | 0.59 | 0.49 | 2.31 | 0.06 |
| Time differences | | | | | | | |
| Shoal Cove | 22 | 20 | 2 | 0.91 | 0.29 | 1.35 | 0.06 |
| George | 22 | 13 | 9 | 0.59 | 0.49 | 2.31 | 0.10 |
| Receivers | | | | | | | |
| Rx(1) | 11 | 2 | 9 | 0.18 | 0.39 | 1.28 | 0.12 |
| Rx(2) | 11 | 11 | 0 | 1.00 | 0.00 | 0.00 | 0.00 |
| Filters | | | | | | | |
| Notches In | 20 | 12 | 8 | 0.60 | 0.49 | 2.10 | 0.11 |
| Notches Out | 2 | 1 | 1 | 0.50 | 0.50 | 0.71 | 0.35 |
| <u>Area #10, Chart #3801(S)</u> | | | | | | | |
| Totals | 34 | 27 | 7 | 0.79 | 0.40 | 1.36 | 0.07 |
| Time differences | | | | | | | |
| Shoal Cove | 34 | 32 | 2 | 0.94 | 0.24 | 1.37 | 0.04 |
| George | 34 | 28 | 6 | 0.82 | 0.38 | 2.22 | 0.07 |
| Receivers | | | | | | | |
| Rx(1) | 17 | 13 | 4 | 0.76 | 0.42 | 1.75 | 0.10 |
| Rx(2) | 17 | 14 | 3 | 0.82 | 0.38 | 1.57 | 0.09 |
| Filters | | | | | | | |
| Notches In | 34 | 27 | 7 | 0.79 | 0.40 | 2.36 | 0.07 |
| <u>Areas #11 and 12*, Charts 3000, 3001 and 3002</u> | | | | | | | |
| Totals | 60 | 52 | 8 | 0.87 | 0.34 | 2.63 | 0.04 |
| Time differences | | | | | | | |
| Shoal Cove | 60 | 52 | 8 | 0.87 | 0.34 | 2.63 | 0.04 |
| George | 60 | 56 | 4 | 0.93 | 0.25 | 1.93 | 0.03 |
| Receivers | | | | | | | |
| Rx(1) | 30 | 27 | 3 | 0.90 | 0.30 | 1.64 | 0.05 |
| Rx(2) | 30 | 25 | 5 | 0.83 | 0.37 | 2.04 | 0.07 |
| Filters | | | | | | | |
| Notches In | 22 | 19 | 3 | 0.86 | 0.34 | 1.61 | 0.07 |
| Notches Out | 38 | 33 | 5 | 0.87 | 0.34 | 2.08 | 0.05 |

* This data was collected between the north end of Vancouver Island and the two hundred mile limit.

APPENDIX 3

Spring 1977 (*Vector*)

Cycle Identification and Signal

Characteristic Data

Cycle Identification Test Data, C.S.S. Vector

Strait of Georgia

Cycle Identification Tests, TD Error

| | <u>California</u> | | <u>B.C.</u> | |
|----------------|-------------------|------------------|-------------------|---------------|
| | <u>George</u> | <u>Middleton</u> | <u>Shoal Cove</u> | <u>George</u> |
| 0 cycle error | 36 | 32 | 24 | 53 |
| 1 cycle error | 11 | 13 | 11 | 0 |
| 2 cycle error | 2 | 1 | 5 | 0 |
| 3 cycle error | 1 | 1 | 7 | 0 |
| >4 cycle error | 1 | 4 | 6 | 0 |
| n | 51 | 51 | 53 | 53 |

Number of Successes

| <u>Receiver</u> | <u>Area of Georgia Strait</u> | | |
|-----------------|-------------------------------|--------------|-----------|
| | <u>North</u> | <u>South</u> | <u>Rx</u> |
| Internav 204 | 10 (22) | 10 (22) | 20 (44) |
| Decca DL 91 | 14 (22) | 10 (22) | 24 (44) |
| Area | 24 (44) | 20 (44) | 44 |

Gain and Noise Data, C.S.S. Vector

From a Calibrated Austron Monitor System

Strait of Georgia

U.S. and Canada West Coast Chains Gains and Noise Numbers

Transformed into microvolts per metre and into DB

Field Strength = $50 \times 10^4 [(110 - \text{Gain } \#) / 20]$

SNR(db) = $10.5 \times \log_{10} (37 / \text{Noise } \#)$ (db above 1 μ volt/metre).

The columns from left to right show the numbers for the Master and for the two secondaries of first the California Chain and then the British Columbia Chain.

The upper number is the field strength and the lower number is signal to noise ratio.

| | <u>M</u> | <u>W</u> | <u>X</u> | <u>M</u> | <u>X</u> | <u>Y</u> |
|-------------------|------------|-------------|------------|------------|--------------|-------------|
| Pat Bay 108 | 899 -24 | 14092 38 | 397 -23 | 4456 1 | 4456* 1 | 15811 26 |
| Haro Strait | 1409 -4 | 19905 38 | 629 -23 | 4456 0 | 17741* 38 | 17741 38 |
| Gulf Islands | 889 -19 | 15811 31 | 354 -25 | 4456 21 | 4456* 21 | 15811 26 |
| Nanaimo 109 | 397 -15 | 9976 38 | 141 -20 | 2812 17 | 706 1 | 9976 38 |
| ACQ B.C.-X | 354 -13 | 11194 38 | 158 -20 | 998 -8 | 79 -28 | 7924 38 |
| Dep. Nanaimo | 397 -15 | 8891 38 | 177 -21 | 2812 38 | 100 -24 | 9976 38 |
| N. Georgia Strait | 792 -6 | 12559 38 | 281 -14 | 3540 31 | 56 -30 | 14092 38 |
| Central Strait | 998 -5 | 14092 38 | 446 -13 | 4456 26 | 7 -36 | 15811 38 |
| Lost B.C.-X | 1119 -2 | 14092 38 | 446 -13 | 4456 26 | 7 -36 | 15811 38 |
| At Gibson's | 998 -6 | 11194 26 | 397 -14 | 3155 14 | 500 -7 | 11194 38 |
| Skywave | 998 -10 | 12559 38 | 354 -15 | 3155 15 | 1256* 3 | 12559 38 |

*Implies not tracking third cycle.

APPENDIX 4

TRIP REPORT, U.S.C.G.C. *FIR*

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Cmdr. R.F. Dugan, U.S.C.G.

Note: Illustrations from the original report have not been reproduced here.

28 November 1977

1. I sailed aboard CGC *FIR* during the period 16 - 19 November 1977. Weather during the trip was good with clear skies and good visibility. The purpose of this trip was to examine the U.S. West Coast Loran-C Chain (Rate 9940) in Puget Sound, the Strait of Georgia and the Strait of Juan de Fuca, and the Canadian Chain (5990) off the coast of Vancouver, B.C. Mr. Norman Porter of the Marine and Electronics Aids Section, Canadian Coast Guard, Ottawa, and Mr. Bob Davis, Canadian Coast Guard, Vancouver, B.C. were aboard to observe the Candian West Coast Loran-C chain (5990) off the west coast of Vancouver. Both gentlemen were extremely helpful and contributed a great deal to the success of the tests. The cooperation of the officers and crew of *FIR* in the utilization of the vessel and providing navigation fix information is appreciated.
2. The following is the itinerary of *FIR* during this trip:
 - a. 11/16 0730 Underway enroute Admiralty Inlet.
 - b. 11/16 1110 Alongside buoy "SB".
 - c. 11/16 1125 Enroute Base Seattle to pick up relief for buoy "SB".
 - d. 11/16 1500 Moored Base Seattle.
 - e. 11/17 0700 Underway enroute Admiralty Inlet.
 - f. 11/17 1025 Alongside buoy "SB".
 - g. 11/17 1125 Relieved buoy "SB" enroute vicinity Vancouver, B.C. via Rosario Strait.
 - h. 11/17 1430 Alongside buoy Rosario "16" to reset on station.
 - i. 11/17 2025 Off Vancouver, B.C. (Point Colan 350° T-7100 yds) enroute Strait of Juan de Fuca via Haro Strait.
 - j. 11/18 0900 Strait of Juan de Fuca, alongside buoy "J" to install RACON.
 - k. 11/18 1005 RACON installed, enroute point 35 miles west of Cape Beale.
 - l. 11/18 1445 Reached point 35 miles west of Cape Beale enroute Base Seattle.
 - m. 11/19 0645 Moored Base Seattle.
3. The Loran-C equipment installed aboard *FIR* consisted to 2 Internav LC-204 receivers, one of which (Rcvr #1) was interfaced to an Epsco Model 4050-10 Loran-C plotter, a Micrologic ML-200 receiver (Rcvr #3) and a Teledyne TDL-708 receiver (Rcvr #4). All receivers were installed on the rail on the starboard side of the flying bridge. The Epsco Plotter did not track the vessel's position accurately during the initial stages of the trip. While no erratic jumps were observed, it continually lagged the vessel's position and was therefore discarded after the first leg of the trip. Failure to track properly is attributed to inexact XY coefficients which were provided by the manufacturer. Comments on the individual receiver performance are provided below.
4. 9940 Tests
 - a. Purpose. Rate 9940 has been observed in the District office since

the first station came on air. In the spring and early summer 1977, cycle selection problems were observed. In April 1977 a transit was made through the Strait of Juan de Fuca and cycle selection problems observed there were reported by Reference (a). At that time we understood that Fallon (ii) was transmitting a -1.5 usec ECD. M is now transmitting $+0.1$ usec ECD. From early summer 1977 to the present, no cycle selection problems have been observed in the District office and therefore observations in Puget Sound were necessary. In addition, the Canadian Communications station, CKN, moved in frequency from 110.75 Khz to 124 Khz in October 1977, and the reduction in interference to Loran-C was of interest. Finally, The Commandant, in reference (b), expressed interest in the possible re-configuration of rate 9940 and therefore verification that signals were usable in the Puget Sound area was deemed necessary.

- b. Area of Tests. As indicated in the itinerary, the tests covered Admiralty Inlet, Rosario Strait, Haro Strait, the Strait of Georgia and the Strait of Juan de Fuca. Actual test results will be broken down as follows:
1. 11/16 Puget Sound/Admiralty Inlet
 2. 11/16 Puget Sound
 3. 11/17 Puget Sound/Admiralty Inlet
 4. 11/17 Admiralty Inlet/Rosario
 5. 11/17 Rosario Strait/Strait of Georgia
 6. 11/17 Strait of Georgia
 7. 11/18 Haro Strait/Strait of Juan de Fuca
 8. 11/18 Strait of Juan de Fuca
 9. 11/19 Entrance Strait of Juan de Fuca
 10. 11/19 Strait of Juan de Fuca/Admiralty Inlet
 11. 11/19 Admiralty Inlet and Puget Sound.
- c. Test Procedure. The tests were conducted in the following manner. Originally I intended to use Receiver #1 and the plotter as the reference. Since no charts were available, the plotter position would provide a valuable reference. When the plotter failed to give an accurate position and Rcvr #2 was found to have some problems in the select position, I decided to use Rcvr #2 in the track position as the reference. In both cases, the reference receiver was locked on, and when all receivers agreed on the TD readout, the reference receiver was put into track. The remaining receivers were cycled, that is, turned off and then on after each TD was recorded. If the readout agreed with the reference receiver, correct cycle identification was established. If the TD was 10 or 20 μ sec high or low when compared with the reference, and all fault indicator lights were extinguished, incorrect cycle selection was assumed. If the receiver locked onto the skywave, or the fault indicator lights were lit, failure to lock-on was assumed. Readings were taken approximately every 20 minutes in areas 1 through 9, and every half hour in areas 10 and 11. The receivers were cycled 96 times during the test and 576 TD's were recorded.

d. Receiver Operation and Test Results

1) Receiver #1 (LC 204) operation was normal throughout the trip. Notches were set on CKM at 76 Khz and 124 Khz. Spectrum as observed on Tektronix 7L13. Spectrum Analyzer was clean. Receiver #1 (LC 204) was used as the reference in areas 1, 2, 3 and 4. The following table shows results for the other areas.

| <u>Area</u> | <u># of Readings</u> | <u>Correct Cycle</u> |
|-------------|----------------------|----------------------|
| 5 | 16 | 16 |
| 6 | 18 | 18 |
| 7 | 22 | 22 |
| 8 | 14 | 14 |
| 9 | 20 | 20 |
| 10 | 22 | 22 |
| 11 | 12 | 12 |
| Total | 124 | 124 |
| % | 100 | 100 |

2) Receiver #2 (LC 204). This receiver had an inoperative notch filter. The remaining notch was set on CKN at 124 Khz. Operation was normal for tests #1 and #2. However, during tests 3 and 4, it exhibited a heat problem and took a long period to lock in. The cover was removed and the receiver (in the track position) was used as the reference for the remainder of the trip. The receiver operated normally when used as a reference except for one incident in the vicinity of Vancouver when the fault indicator lights came on and it jumped down 10 μ sec. It was then placed in the select position and immediately jumped up 10 μ sec. The indicator lights extinguished, and the receiver was put back into track. The following are the test results.

| Area | # of Readings | # Lock Correct Cycle | Incorrect Cycle | | | Fail to Lock | |
|-------|---------------|----------------------|-----------------|---|-----|--------------|-----|
| | | | M | W | X | MW | MX |
| 1 | 20 | 18 | 1 | | | | |
| 2 | 6 | 6 | | | | | |
| 3 | 22 | 19 | 2 | | 1 | | |
| 4 | 20 | 17 | 1 | | 2 | | |
| Total | 68 | 60 | 4 | 0 | 3 | 0 | 1 |
| % | 100 | 88.8 | 5.9 | 0 | 4.4 | 0 | 1.4 |

3) Receiver #3 (ML 200). This receiver operated irratically throughout the trip. When viewed on the spectrum analyzer, it appeared that it was picking up an 18 Khz signal whose amplitude was within 20 db of the Loran-C amplitude from LorSta George. This was assumed to be local pick-up onboard *FIR* since the spectrum was clean when operated before and after the trip in the District office. It was later determined that the interfering 18 Khz signal was actually

conduction through the power cable from the TDL-708 (Rcvr #4). I attribute the difficulties with receiver #3 to this interfering 18 Khz signal. Enclosure (3) provides spectrum analyzer photos of the interference as seen on the ML 200. This interference disappeared when the TDL-708 was operated through an isolation transformer. On a number of occasions, the receiver would display a warning light with a TD approximately 200-500 μ sec high. When it was cycled or jumped near the correct TD, it would then lock on. Notches were set as follows: One on CKN at 76 Khz; 2 on CKN at 124 Khz; one on another signal between 124 and 130 Khz. Results of the tests are as follows:

| Area | # of Readings | # Lock Correct Cycle | Incorrect Cycle | | | Fail to Lock | |
|-------|---------------|----------------------|-----------------|---|-----|--------------|------|
| | | | M | W | X | MW | MX |
| 1 | 20 | 17 | | | | 2 | 1 |
| 2 | 6 | 6 | | | | | |
| 3 | 22 | 21 | | | | 1 | |
| 4 | 20 | 19 | | | | | 1 |
| 5 | 16 | 10 | | | | 2 | 4 |
| 6 | 18 | 8 | | | | 2 | 8 |
| 7 | 22 | 7 | 1 | | 1 | 5 | 8 |
| 8 | 14 | 10 | 2 | | 2 | | |
| 9 | 20 | 6 | | | | 5 | 9 |
| 10 | 22 | 7 | | | | 6 | 9 |
| 11 | 12 | 9 | 1 | | 1 | | |
| TOTAL | 192 | 120 | | | | 24 | 40 |
| % | 100 | 62.4 | 2.3 | 0 | 2.0 | 12.5 | 20.8 |

4) Receiver #4 (TDL 708). This receiver has a wide bandwidth when compared to the LC 204. Unfortunately, the oscilloscope carried onboard failed. Therefore I was unable to set the notch filters on the interfering signals from CKN. The notches were set approximately on 76 and 124 Khz, judging from the scale on the back of the case. It is apparent from the results that the notches were not set properly. In the Vancouver area (areas 4, 5, 6 and 7) where CKN is strong, the receiver was virtually useless. The TDL 708 is a frustrating receiver to operate. When it locks on the skywave as it did on eleven (11) occasions, and the operator is aware that it is on the skywave, there is nothing he can do but cycle the receiver. Each of the other receivers can be jumped ahead to the groundwave. Another feature which the TDL 708 lacks is the ability to set the receiver in the track position. Results of the tests are as follows:

| Area | # of Readings | # Lock Correct Cycle | Incorrect Cycle | | | Fail to Lock | |
|-------|---------------|----------------------|-----------------|---|-----|--------------|------|
| | | | M | W | X | MW | MX |
| 1 | 20 | 20 | | | | | |
| 2 | 6 | 6 | | | | | |
| 3 | 22 | 21 | | | | | |
| 4 | 20 | 12 | | | 1 | 3 | 4 |
| 5 | 16 | 3 | | | 1 | 5 | 8 |
| 6 | 18 | 6 | | | 1 | 3 | 8 |
| 7 | 22 | 12 | 1 | | 3 | 1 | 5 |
| 8 | 14 | 14 | | | | | |
| 9 | 20 | 17 | | | | | 3 |
| 10 | 22 | 14 | | | 1 | 3 | 4 |
| 11 | 12 | 12 | | | | | |
| TOTAL | 192 | 137 | 1 | | 7 | 15 | 32 |
| % | 100 | 71.5 | 0.5 | | 3.6 | 7.8 | 16.6 |

- e. Conclusions. Analysis of the test results leads to the conclusion that there are no signal strength or cycle selection problems with the Loran-C chain in Puget Sound in the areas transmitted. It also follows that in order to use the system, the receiver used must be operating properly with notch filters set correctly.

5. 5990 Tests

- a. Purpose. The purpose of this test was to determine if cycle selection problems exist off the Canadian Coast. It was done at the request of the Canadian government. Although the message formally requesting it was never received in the 13th District, an informal request was received via telephone. Enclosure (1) details problems the Canadians have had utilizing the chain in the area 35 miles west of Cape Beale. A survey was done by the Canadian Hydrographic Service in the spring of 1977 prior to the chain becoming operational. The results of this survey showed that correct cycle selection in the area of interest was extremely poor. The receivers used locked on to the wrong cycle more than 40% of the time. Discussions with 5990 COCO fail to reveal what ECD's the stations were transmitting at that time since each station was adjusting its pulse shape independently. Currently the 9940 station ECD's are as follows:

| STATION | TRANSMITTED ECD | ECD SEEN AT | |
|---------|--------------------|-------------|-----|
| | | ALERT | BAY |
| M | 0 | + .7 | |
| X | + .8 | +1.6 | |
| Y | 0 | -0.2 | |

- b. Area of Tests. The tests on rate 5990 were conducted in two sectors. The first sector was from a point one mile north of Waadah Island in The Strait of Juan de Fuca to a point 10 miles south of Cape Beale on Vancouver Island. The second sector was the point 10 miles south of Cape Beale to a point 35 miles west of Cape Beale. (Notice to Mariners #43 dated 10 Nov. 1977 warns that Mariners should exercise caution using 5990 from Cape Beale through the Strait of Juan de Fuca.)
- c. Test Procedure. Test procedures used were identical to those used for rate 9940. Receiver #2 was used as the reference for these tests. In addition since a chart was available, the Loran-C fixes were plotted along with visual and/or radar fixes.
- d. Receiver Operation and Test Results.
 - 1. Operation east of Cape Beale. The receivers were cycled nine times east of Cape Beale. All receivers locked on to the correct cycle for the MY pair on each attempt. Receiver #1 (LC 204) locked on to the correct X cycle in 7 cases and on to the X skywave 2 times. When it was on the skywave, it could be jumped down 30 μ sec and would then lock on to the groundwave. Receiver #3 (ML 200) locked on to the X skywave or failed to lock on in all nine attempts. Receiver #4 locked on to the skywave in 8 cases and failed to lock on in the ninth.
 - 2. Operation west of Cape Beale. Each of the test receivers were cycled 19 times in this area. There were 114 TD's recorded. Each receiver in all 19 attempts, locked on to the correct cycle. The TD's were plotted and each fix fell within one-half mile of the vessel's visual/radar fix. Enclosure (2) is the chart on which the fixes are plotted.
- e. Conclusions
 - 1. Notice to Mariners #48 gives the proper precaution for navigating using 5990 east of Cape Beale. However, it is possible to use this rate in this area if a sensitive receiver is used, and if the operator recognizes the X skywave and jumps the receiver down to the groundwave.
 - 2. Operation of the Rate 5990 west of Cape Beale is outstanding. Signals are strong from all stations and there are no cycle selection problems. Even with marginal receivers (ML 200), correct cycle selection can be expected.
 - 3. The failure of the Canadian Hydrographic Service to achieve good cycle selection was probably due to the fact that the transmitted ECD's were not being controlled when the survey was taken.
- f. Recommendations. In view of the poor publicity and legal aspects of the Loran-C chain accuracy in the area west of Cape Beale, I recommend that the Canadian government be advised to conduct another survey in that area.

APPENDIX 5

Autumn 1978 (*Parizeau*)

Cycle Identification Data

Descriptive Statistics

NOTATIONFirst Summary ArrayColumn #

| | |
|----|---|
| 1 | Number of tests in which the signal was acquired within 5 min. |
| 2 | Number of tests in which the signal was acquired within 10 min. |
| 3 | Number of tests in which the signal was acquired within 15 min. |
| 4 | Number of tests in which the signal was acquired within 20 min. |
| 5 | Number of tests in which the signal was acquired within >20 min. |
| 6 | Number of Successful TD-X(W) Acquisitions. |
| 7 | Number of Unsuccessful TD-X(W) Acquisitions. |
| 8 | Number of TD-X(W) Acquisitions in error by - 10 microsecs. |
| 9 | Number of TD-X(W) Acquisitions in error by + 10 microsecs. |
| 10 | Number of TD-X(W) Acquisitions in error by + 20 microsecs. |
| 11 | Number of TD-X(W) Acquisitions in error by > 20 microsecs. |
| 12 | Number of Successful TD-Y(X) Acquisitions. |
| 13 | Number of Unsuccessful TD-Y(X) Acquisitions. |
| 14 | Number of TD-Y(X) Acquisitions in error by - 10 microsecs. |
| 15 | Number of TD-Y(X) Acquisitions in error by + 10 microsecs. |
| 16 | Number of TD-Y(X) Acquisitions in error by + 20 microsecs. |
| 17 | Number of TD-Y(X) Acquisitions in error by > 20 microsecs. |
| 18 | Number of Successful Tracking Tests. |
| 19 | Number of Successful Acquisition Tests, both T.D.'s. |
| 20 | Number of Potentially Hazardous Test Results. |
| 21 | Row 1 = G.R.I., Rows 2,3,4 = Cycle Nos., Master, X(W), Y(X), Row 5 = # Tests per receiver, Row 6 = Total # of Tests. |

Time Statistics ArrayColumn #

| | |
|----|---|
| 1 | Average Time to Acquire. |
| 2 | Average Time to Acquire Standard Deviation. |
| 3 | Proportion taking < 5 mins. |
| 4 | Proportion taking < 5 mins. Standard Deviation. |
| 5 | Proportion taking <10 mins. |
| 6 | Proportion taking <10 mins. Standard Deviation. |
| 7 | Proportion taking <15 mins. |
| 8 | Proportion taking <15 mins. Standard Deviation. |
| 9 | Proportion taking <20 mins. |
| 10 | Proportion taking <20 mins. Standard Deviation. |
| 11 | Proportion taking >20 mins. |
| 12 | Proportion taking >20 mins. Standard Deviation. |

Note: U.S. West Coast Chain secondaries given in parentheses.

X and Y Secondary Statistics Arrays

for U.S. West Coast Chain, let $X = W$ and $Y = X$.

Column

| | | |
|----|---|--------------------|
| 1 | Proportion of Successful Acquisitions. | |
| 2 | Proportion of Successful Acquisitions Standard Deviation. | |
| 3 | Proportion of Unsuccessful Acquisitions. | |
| 4 | Proportion of Unsuccessful Acquisitions Standard Deviation. | |
| 5 | Proportion of Acquisitions in Error by - 10 microseconds. | |
| 6 | Proportion (Std. Dev.) | |
| 7 | Proportion | + 10 microseconds. |
| 8 | Proportion (Std. Dev.) | |
| 9 | Proportion | + 20 microseconds. |
| 10 | Proportion (Std. Dev.) | |
| 11 | Proportion | > 20 microseconds. |
| 12 | Proportion (Std. Dev.) | |

Track and Total Statistics Array

Column

| | |
|---|---|
| 1 | Proportion of Successful Tracking Tests. |
| 2 | Proportion Standard Deviation. |
| 3 | Proportion of Successful Acquisitions Tests, Both T.D.'s. |
| 4 | Proportion Standard Deviation. |
| 5 | Proportion of Potentially Hazardous Test Results. |
| 6 | Proportion Standard Deviation. |

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| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---------------|----|----|---|----|---|----|----|---|---|----|----|----|----|----|----|----|----|----|----|----|---------|
| Internav 204 | 0 | 6 | 2 | 4 | 0 | 5 | 7 | 1 | 1 | 0 | 5 | 10 | 2 | 0 | 1 | 0 | 1 | 7 | 5 | 2 | 5990.00 |
| Internav 123 | 5 | 7 | 0 | 0 | 0 | 4 | 8 | 1 | 0 | 1 | 6 | 12 | 0 | 0 | 0 | 0 | 0 | 8 | 4 | 2 | 2.97 |
| Decca DL91 | 2 | 5 | 0 | 4 | 1 | 1 | 11 | 1 | 0 | 0 | 10 | 9 | 3 | 0 | 0 | 1 | 2 | 7 | 1 | 2 | 3.10 |
| S.R.D.(c) | 4 | 3 | 1 | 4 | 0 | 4 | 8 | 0 | 0 | 0 | 8 | 10 | 2 | 0 | 0 | 0 | 2 | 6 | 3 | 0 | 2.94 |
| T.I. 9000a | 1 | 1 | 3 | 6 | 1 | 0 | 12 | 0 | 0 | 2 | 10 | 9 | 3 | 0 | 1 | 0 | 2 | 3 | 0 | 3 | 12.00 |
| All Receivers | 12 | 22 | 6 | 18 | 2 | 14 | 46 | 3 | 1 | 3 | 39 | 50 | 10 | 0 | 2 | 1 | 7 | 31 | 13 | 9 | 60.00 |

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Time Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|-------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 12.42 | 3.52 | 0.00 | 0.00 | 0.50 | 0.15 | 0.17 | 0.11 | 0.33 | 0.14 | 0.00 | 0.00 |
| Internav 123 | 5.75 | 2.40 | 0.42 | 0.15 | 0.58 | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Decca DL91 | 12.03 | 3.48 | 0.17 | 0.11 | 0.42 | 0.15 | 0.00 | 0.00 | 0.33 | 0.14 | 0.08 | 0.08 |
| S.R.D.(c) | 11.17 | 3.34 | 0.33 | 0.14 | 0.25 | 0.13 | 0.08 | 0.08 | 0.33 | 0.14 | 0.00 | 0.00 |
| T.I. 9000a | 15.33 | 3.92 | 0.08 | 0.08 | 0.08 | 0.08 | 0.25 | 0.13 | 0.50 | 0.15 | 0.08 | 0.08 |
| All Receivers | 11.35 | 3.37 | 0.20 | 0.05 | 0.37 | 0.06 | 0.10 | 0.04 | 0.30 | 0.06 | 0.03 | 0.02 |

X-secondary Statistics

| Cclurn # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 0.42 | 0.15 | 0.58 | 0.15 | 0.08 | 0.08 | 0.08 | 0.08 | 0.00 | 0.00 | 0.42 | 0.15 |
| Internav 123 | 0.33 | 0.14 | 0.67 | 0.14 | 0.08 | 0.08 | 0.00 | 0.00 | 0.08 | 0.08 | 0.50 | 0.15 |
| Decca DL91 | 0.08 | 0.08 | 0.92 | 0.08 | 0.08 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.83 | 0.11 |
| S.R.D.(c) | 0.33 | 0.14 | 0.67 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.67 | 0.14 |
| T.I.9000a | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.17 | 0.11 | 0.83 | 0.11 |
| All Receivers | 0.23 | 0.06 | 0.77 | 0.06 | 0.05 | 0.03 | 0.02 | 0.02 | 0.05 | 0.03 | 0.65 | 0.06 |

Y-secondary Statistics

| Cclurn # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 0.83 | 0.11 | 0.17 | 0.11 | 0.00 | 0.00 | 0.08 | 0.08 | 0.00 | 0.00 | 0.08 | 0.08 |
| Internav 123 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Decca DL91 | 0.75 | 0.13 | 0.25 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.08 | 0.17 | 0.11 |
| S.R.D.(c) | 0.83 | 0.11 | 0.17 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.17 | 0.11 |
| T.I.9000a | 0.75 | 0.13 | 0.25 | 0.13 | 0.00 | 0.00 | 0.08 | 0.08 | 0.00 | 0.00 | 0.17 | 0.11 |
| All Receivers | 0.83 | 0.05 | 0.17 | 0.05 | 0.00 | 0.00 | 0.03 | 0.02 | 0.02 | 0.02 | 0.12 | 0.04 |

| Column # | Track & Total Statistics | | | | | |
|---------------|--------------------------|------|------|------|------|------|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Internav 204 | 0.58 | 0.15 | 0.42 | 0.15 | 0.17 | 0.11 |
| Internav 123 | 0.67 | 0.14 | 0.33 | 0.14 | 0.17 | 0.11 |
| Decca DL91 | 0.58 | 0.15 | 0.08 | 0.08 | 0.17 | 0.11 |
| S.R.D.(c) | 0.50 | 0.15 | 0.25 | 0.13 | 0.00 | 0.00 |
| T.I.9000a | 0.25 | 0.13 | 0.00 | 0.00 | 0.25 | 0.13 |
| All Receivers | 0.52 | 0.07 | 0.22 | 0.05 | 0.15 | 0.05 |

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| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---------------|----|----|---|----|---|----|----|---|---|----|-----|-----|----|----|----|----|----|----|----|----|---------|
| Internav 204 | 1 | 12 | 1 | 7 | 0 | 14 | 7 | 2 | 2 | 1 | 2 | 18 | 3 | 1 | 1 | 0 | 1 | 19 | 13 | 6 | 5990.00 |
| Internav 123 | 15 | 7 | 0 | 0 | 1 | 22 | 1 | 0 | 1 | 0 | 0 | 23 | 0 | 0 | 0 | 0 | 0 | 23 | 22 | 1 | 2.98 |
| Decca DL91 | 2 | 15 | 1 | 5 | 0 | 16 | 7 | 0 | 0 | 0 | 7 | 21 | 2 | 1 | 0 | 0 | 1 | 16 | 15 | 1 | 3.03 |
| S.R.D.(c) | 9 | 4 | 4 | 6 | 0 | 19 | 4 | 0 | 1 | 0 | 3 | 19 | 4 | 0 | 0 | 0 | 4 | 17 | 16 | 1 | 2.94 |
| T.I.9000a | 7 | 0 | 2 | 14 | 0 | 11 | 12 | 7 | 0 | 0 | 5 | 22 | 1 | 0 | 0 | 0 | 1 | 14 | 11 | 7 | 23.00 |
| All Receivers | 34 | 38 | 8 | 32 | 1 | 82 | 31 | 9 | 4 | 1 | 171 | 103 | 10 | 2 | 1 | 0 | 7 | 89 | 77 | 16 | 115.00 |

Time Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|-------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 10.91 | 3.30 | 0.04 | 0.04 | 0.52 | 0.11 | 0.04 | 0.04 | 0.30 | 0.10 | 0.00 | 0.00 |
| Internav 123 | 6.83 | 2.61 | 0.65 | 0.10 | 0.30 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.04 |
| Decca DL91 | 10.04 | 3.17 | 0.09 | 0.06 | 0.65 | 0.10 | 0.04 | 0.04 | 0.22 | 0.09 | 0.00 | 0.00 |
| S.R.D.(c) | 10.48 | 3.24 | 0.39 | 0.10 | 0.17 | 0.08 | 0.17 | 0.08 | 0.26 | 0.09 | 0.00 | 0.00 |
| T.I.9000a | 14.04 | 3.75 | 0.30 | 0.10 | 0.00 | 0.00 | 0.09 | 0.06 | 0.61 | 0.10 | 0.00 | 0.00 |
| All Receivers | 10.46 | 3.23 | 0.30 | 0.04 | 0.33 | 0.04 | 0.07 | 0.02 | 0.28 | 0.04 | 0.01 | 0.01 |

X-secondary Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 0.61 | 0.10 | 0.30 | 0.10 | 0.09 | 0.06 | 0.09 | 0.06 | 0.04 | 0.04 | 0.09 | 0.06 |
| Internav 123 | 0.96 | 0.04 | 0.04 | 0.04 | 0.00 | 0.00 | 0.04 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 |
| Decca DL91 | 0.70 | 0.10 | 0.30 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.30 | 0.10 |
| S.R.D.(c) | 0.83 | 0.08 | 0.17 | 0.08 | 0.00 | 0.00 | 0.04 | 0.04 | 0.00 | 0.00 | 0.13 | 0.07 |
| T.I.9000a | 0.48 | 0.11 | 0.52 | 0.11 | 0.30 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.22 | 0.09 |
| All Receivers | 0.71 | 0.04 | 0.27 | 0.04 | 0.08 | 0.03 | 0.03 | 0.02 | 0.01 | 0.01 | 0.15 | 0.03 |

Y-secondary Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 0.78 | 0.09 | 0.13 | 0.07 | 0.04 | 0.04 | 0.04 | 0.04 | 0.00 | 0.00 | 0.04 | 0.04 |
| Internav 123 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Decca DL91 | 0.91 | 0.06 | 0.09 | 0.06 | 0.04 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.04 |
| S.R.D.(c) | 0.83 | 0.08 | 0.17 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.17 | 0.08 |
| T.I.9000a | 0.96 | 0.04 | 0.04 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.04 |
| All Receivers | 0.90 | 0.03 | 0.09 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.06 | 0.02 |

Track & Total Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 |
|---------------|------|------|------|------|------|------|
| Internav 204 | 0.83 | 0.08 | 0.57 | 0.11 | 0.26 | 0.09 |
| Internav 123 | 1.00 | 0.00 | 0.96 | 0.04 | 0.04 | 0.04 |
| Decca DL91 | 0.70 | 0.10 | 0.65 | 0.10 | 0.04 | 0.04 |
| S.R.D.(c) | 0.74 | 0.09 | 0.70 | 0.10 | 0.04 | 0.04 |
| T.I.9000a | 0.61 | 0.10 | 0.48 | 0.11 | 0.30 | 0.10 |
| All Receivers | 0.77 | 0.04 | 0.67 | 0.04 | 0.14 | 0.03 |

WEST CANADIAN CHAIN - DAY 328

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---------------|----|----|---|----|---|----|----|---|---|----|----|----|----|----|----|----|----|----|----|----|---------|
| Internav 204 | 0 | 10 | 0 | 11 | 0 | 5 | 16 | 0 | 1 | 2 | 13 | 18 | 3 | 0 | 1 | 0 | 2 | 13 | 5 | 3 | 5990.00 |
| Internav 123 | 11 | 10 | 0 | 0 | 0 | 11 | 10 | 2 | 2 | 0 | 6 | 21 | 0 | 0 | 0 | 0 | 0 | 20 | 11 | 4 | 2.96 |
| Decca DL91 | 2 | 11 | 2 | 6 | 0 | 4 | 17 | 0 | 0 | 1 | 16 | 16 | 5 | 0 | 1 | 0 | 4 | 3 | 2 | 2 | 3.12 |
| S.R.D.(c) | 11 | 5 | 2 | 2 | 0 | 2 | 18 | 0 | 0 | 1 | 17 | 20 | 0 | 0 | 0 | 0 | 0 | 17 | 2 | 1 | 2.93 |
| T.I.9000a | 2 | 12 | 3 | 4 | 0 | 2 | 19 | 1 | 0 | 0 | 18 | 18 | 3 | 0 | 1 | 0 | 2 | 5 | 1 | 2 | 21.00 |
| All Receivers | 26 | 48 | 7 | 23 | 0 | 24 | 80 | 3 | 3 | 4 | 70 | 93 | 11 | 0 | 3 | 0 | 8 | 58 | 21 | 12 | 105.00 |

Time Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|-------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 14.38 | 3.79 | 0.00 | 0.00 | 0.48 | 0.11 | 0.00 | 0.00 | 0.52 | 0.11 | 0.00 | 0.00 |
| Internav 123 | 6.19 | 2.49 | 0.52 | 0.11 | 0.48 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Decca DL91 | 11.52 | 3.39 | 0.10 | 0.07 | 0.52 | 0.11 | 0.10 | 0.07 | 0.29 | 0.10 | 0.00 | 0.00 |
| S.R.D.(c) | 7.52 | 2.74 | 0.52 | 0.11 | 0.24 | 0.10 | 0.10 | 0.07 | 0.10 | 0.07 | 0.00 | 0.00 |
| T.I.9000a | 10.48 | 3.24 | 0.10 | 0.07 | 0.57 | 0.11 | 0.14 | 0.08 | 0.19 | 0.09 | 0.00 | 0.00 |
| All Receivers | 10.02 | 3.17 | 0.25 | 0.04 | 0.46 | 0.05 | 0.07 | 0.02 | 0.22 | 0.04 | 0.00 | 0.00 |

X-secondary Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 0.24 | 0.10 | 0.76 | 0.10 | 0.00 | 0.00 | 0.05 | 0.05 | 0.10 | 0.07 | 0.62 | 0.11 |
| Internav 123 | 0.52 | 0.11 | 0.48 | 0.11 | 0.10 | 0.07 | 0.10 | 0.07 | 0.00 | 0.00 | 0.29 | 0.10 |
| Decca DL91 | 0.19 | 0.09 | 0.81 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.05 | 0.76 | 0.10 |
| S.R.D.(c) | 0.10 | 0.07 | 0.86 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.05 | 0.81 | 0.09 |
| T.I.9000a | 0.10 | 0.07 | 0.90 | 0.07 | 0.05 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.86 | 0.08 |
| All Receivers | 0.23 | 0.04 | 0.76 | 0.04 | 0.03 | 0.02 | 0.03 | 0.02 | 0.04 | 0.02 | 0.67 | 0.05 |

Y-secondary Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 0.86 | 0.08 | 0.14 | 0.08 | 0.00 | 0.00 | 0.05 | 0.05 | 0.00 | 0.00 | 0.10 | 0.07 |
| Internav 123 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Decca DL91 | 0.76 | 0.10 | 0.24 | 0.10 | 0.00 | 0.00 | 0.05 | 0.05 | 0.00 | 0.00 | 0.19 | 0.09 |
| S.R.D.(c) | 0.95 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| T.I.9000a | 0.86 | 0.08 | 0.14 | 0.08 | 0.00 | 0.00 | 0.05 | 0.05 | 0.00 | 0.00 | 0.10 | 0.07 |
| All Receivers | 0.89 | 0.03 | 0.10 | 0.03 | 0.00 | 0.00 | 0.03 | 0.02 | 0.00 | 0.00 | 0.08 | 0.03 |

Track & Total Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 |
|---------------|------|------|------|------|------|------|
| Internav 204 | 0.62 | 0.11 | 0.24 | 0.10 | 0.14 | 0.08 |
| Internav 123 | 0.95 | 0.05 | 0.52 | 0.11 | 0.19 | 0.09 |
| Decca DL91 | 0.14 | 0.08 | 0.10 | 0.07 | 0.10 | 0.07 |
| S.R.D.(c) | 0.81 | 0.09 | 0.10 | 0.07 | 0.05 | 0.05 |
| T.I.9000a | 0.24 | 0.10 | 0.05 | 0.05 | 0.10 | 0.07 |
| All Receivers | 0.55 | 0.05 | 0.20 | 0.04 | 0.11 | 0.03 |

WEST CANADIAN CHAIN - DAY 329

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---------------|----|----|----|----|---|----|----|---|----|----|----|-----|----|----|----|----|----|----|----|----|---------|
| Internav 204 | 0 | 16 | 4 | 4 | 0 | 19 | 5 | 2 | 1 | 2 | 0 | 22 | 2 | 1 | 1 | 0 | 0 | 23 | 19 | 5 | 5990.00 |
| Internav 123 | 13 | 10 | 1 | 0 | 0 | 18 | 6 | 1 | 2 | 1 | 2 | 24 | 0 | 0 | 0 | 0 | 0 | 23 | 18 | 4 | 2.98 |
| Decca DL91 | 2 | 16 | 3 | 3 | 0 | 14 | 10 | 0 | 3 | 1 | 6 | 24 | 0 | 0 | 0 | 0 | 0 | 17 | 14 | 4 | 2.94 |
| S.R.D.(c) | 11 | 4 | 4 | 5 | 0 | 17 | 7 | 0 | 3 | 2 | 2 | 22 | 2 | 0 | 0 | 0 | 2 | 18 | 16 | 5 | 2.94 |
| T.I.9000a | 4 | 5 | 4 | 11 | 0 | 9 | 15 | 1 | 2 | 3 | 9 | 20 | 4 | 1 | 0 | 0 | 3 | 14 | 8 | 7 | 24.00 |
| All Receivers | 30 | 51 | 16 | 23 | 0 | 77 | 43 | 4 | 11 | 9 | 19 | 112 | 8 | 2 | 1 | 0 | 5 | 95 | 75 | 25 | 120.00 |

Time Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|-------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 10.33 | 3.21 | 0.00 | 0.00 | 0.67 | 0.10 | 0.17 | 0.08 | 0.17 | 0.08 | 0.00 | 0.00 |
| Internav 123 | 6.04 | 2.46 | 0.54 | 0.10 | 0.42 | 0.10 | 0.04 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 |
| Decca DL91 | 10.04 | 3.17 | 0.08 | 0.06 | 0.67 | 0.10 | 0.13 | 0.07 | 0.13 | 0.07 | 0.00 | 0.00 |
| S.R.D.(c) | 9.25 | 3.04 | 0.46 | 0.10 | 0.17 | 0.08 | 0.17 | 0.08 | 0.21 | 0.08 | 0.00 | 0.00 |
| T.I.9000a | 13.54 | 3.68 | 0.17 | 0.08 | 0.21 | 0.08 | 0.17 | 0.08 | 0.46 | 0.10 | 0.00 | 0.00 |
| All Receivers | 9.84 | 3.14 | 0.25 | 0.04 | 0.43 | 0.05 | 0.13 | 0.03 | 0.19 | 0.04 | 0.00 | 0.00 |

X-secondary Statistics

| Cclurn # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 0.79 | 0.08 | 0.21 | 0.08 | 0.08 | 0.06 | 0.04 | 0.04 | 0.08 | 0.06 | 0.00 | 0.00 |
| Internav 123 | 0.75 | 0.09 | 0.25 | 0.09 | 0.04 | 0.04 | 0.08 | 0.06 | 0.04 | 0.04 | 0.08 | 0.06 |
| Decca DL91 | 0.58 | 0.10 | 0.42 | 0.10 | 0.00 | 0.00 | 0.13 | 0.07 | 0.04 | 0.04 | 0.25 | 0.09 |
| S.R.D.(c) | 0.71 | 0.09 | 0.29 | 0.09 | 0.00 | 0.00 | 0.13 | 0.07 | 0.08 | 0.06 | 0.08 | 0.06 |
| T.I. 9000a | 0.38 | 0.10 | 0.63 | 0.10 | 0.04 | 0.04 | 0.08 | 0.06 | 0.13 | 0.07 | 0.38 | 0.10 |
| All Receivers | 0.64 | 0.04 | 0.36 | 0.04 | 0.03 | 0.02 | 0.09 | 0.03 | 0.08 | 0.02 | 0.16 | 0.03 |

Y-secondary Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 0.92 | 0.06 | 0.08 | 0.06 | 0.04 | 0.04 | 0.04 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 |
| Internav 123 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Decca DL91 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| S.R.D.(c) | 0.92 | 0.06 | 0.08 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.06 |
| T.I. 9000a | 0.83 | 0.08 | 0.17 | 0.08 | 0.04 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.07 |
| All Receivers | 0.93 | 0.02 | 0.07 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.04 | 0.02 |

Track & Total Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 |
|---------------|------|------|------|------|------|------|
| Internav 204 | 0.96 | 0.04 | 0.79 | 0.08 | 0.21 | 0.08 |
| Internav 123 | 0.96 | 0.04 | 0.75 | 0.09 | 0.17 | 0.08 |
| Decca DL91 | 0.71 | 0.09 | 0.58 | 0.10 | 0.17 | 0.08 |
| S.R.D.(c) | 0.75 | 0.09 | 0.67 | 0.10 | 0.21 | 0.08 |
| T.I.9000a | 0.58 | 0.10 | 0.33 | 0.10 | 0.29 | 0.09 |
| All Receivers | 0.79 | 0.04 | 0.63 | 0.04 | 0.21 | 0.04 |

U.S. WEST COAST CHAIN - DAY 326

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---------------|---|----|---|----|---|----|---|---|---|----|----|----|----|----|----|----|----|----|----|----|---------|
| Internav 204 | 0 | 1 | 4 | 6 | 0 | 9 | 2 | 0 | 1 | 0 | 1 | 6 | 5 | 4 | 0 | 0 | 1 | 10 | 6 | 4 | 9940.00 |
| Internav 123 | 0 | 9 | 1 | 1 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 9 | 2 | 0 | 2 | 0 | 0 | 11 | 9 | 2 | 2.97 |
| Decca DL91 | 0 | 2 | 2 | 7 | 0 | 10 | 1 | 0 | 0 | 0 | 1 | 4 | 7 | 1 | 1 | 0 | 5 | 3 | 4 | 2 | 2.99 |
| S.R.D.(c) | 2 | 5 | 1 | 3 | 0 | 9 | 2 | 0 | 0 | 0 | 2 | 8 | 3 | 1 | 0 | 0 | 2 | 8 | 8 | 1 | 3.11 |
| T.I.9000a | 1 | 0 | 0 | 10 | 0 | 7 | 4 | 0 | 3 | 0 | 1 | 2 | 9 | 2 | 1 | 0 | 6 | 2 | 2 | 5 | 11.00 |
| All Receivers | 3 | 17 | 8 | 27 | 0 | 46 | 9 | 0 | 4 | 0 | 5 | 29 | 26 | 8 | 4 | 0 | 14 | 34 | 29 | 14 | 55.00 |

Time Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|-------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 16.36 | 4.05 | 0.00 | 0.00 | 0.09 | 0.09 | 0.36 | 0.15 | 0.55 | 0.16 | 0.00 | 0.00 |
| Internav 123 | 9.27 | 3.05 | 0.00 | 0.00 | 0.82 | 0.12 | 0.09 | 0.09 | 0.09 | 0.09 | 0.00 | 0.00 |
| Decca DL91 | 16.45 | 4.06 | 0.00 | 0.00 | 0.18 | 0.12 | 0.18 | 0.12 | 0.64 | 0.15 | 0.00 | 0.00 |
| S.R.D.(c) | 11.27 | 3.36 | 0.18 | 0.12 | 0.45 | 0.16 | 0.09 | 0.09 | 0.27 | 0.14 | 0.00 | 0.00 |
| T.I.9000a | 17.09 | 4.13 | 0.09 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.91 | 0.09 | 0.00 | 0.00 |
| All Receivers | 14.09 | 3.75 | 0.05 | 0.03 | 0.31 | 0.06 | 0.15 | 0.05 | 0.49 | 0.07 | 0.00 | 0.00 |

X-secondary Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 0.82 | 0.12 | 0.18 | 0.12 | 0.00 | 0.00 | 0.09 | 0.09 | 0.00 | 0.00 | 0.09 | 0.09 |
| Internav 123 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Decca DL91 | 0.91 | 0.09 | 0.09 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.09 |
| S.R.D.(c) | 0.82 | 0.12 | 0.18 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.18 | 0.12 |
| T.I. 9000a | 0.64 | 0.15 | 0.36 | 0.15 | 0.00 | 0.00 | 0.27 | 0.14 | 0.00 | 0.00 | 0.09 | 0.09 |
| All Receivers | 0.84 | 0.05 | 0.16 | 0.05 | 0.00 | 0.00 | 0.07 | 0.04 | 0.00 | 0.00 | 0.09 | 0.04 |

Y-secondary Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 0.55 | 0.16 | 0.45 | 0.16 | 0.36 | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.09 |
| Internav 123 | 0.82 | 0.12 | 0.18 | 0.12 | 0.00 | 0.00 | 0.18 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 |
| Decca LL91 | 0.36 | 0.15 | 0.64 | 0.15 | 0.09 | 0.09 | 0.09 | 0.09 | 0.00 | 0.00 | 0.45 | 0.16 |
| S.R.D.(c) | 0.73 | 0.14 | 0.27 | 0.14 | 0.09 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.18 | 0.12 |
| T.I. 9000a | 0.18 | 0.12 | 0.82 | 0.12 | 0.18 | 0.12 | 0.09 | 0.09 | 0.00 | 0.00 | 0.55 | 0.16 |
| All Receivers | 0.53 | 0.07 | 0.47 | 0.07 | 0.15 | 0.05 | 0.07 | 0.04 | 0.00 | 0.00 | 0.25 | 0.06 |

Track & Total Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 |
|---------------|------|------|------|------|------|------|
| Internav 204 | 0.91 | 0.09 | 0.55 | 0.16 | 0.36 | 0.15 |
| Internav 123 | 1.00 | 0.00 | 0.82 | 0.12 | 0.18 | 0.12 |
| Decca DL91 | 0.27 | 0.14 | 0.36 | 0.15 | 0.18 | 0.12 |
| S.R.D.(c) | 0.73 | 0.14 | 0.73 | 0.14 | 0.09 | 0.09 |
| T.I.9000a | 0.18 | 0.12 | 0.18 | 0.12 | 0.45 | 0.16 |
| All Receivers | 0.62 | 0.07 | 0.53 | 0.07 | 0.25 | 0.06 |

U.S. WEST COAST CHAIN - DAY 327

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---------------|---|----|----|----|---|----|----|---|---|----|----|----|----|----|----|----|----|----|----|----|---------|
| Internav 204 | 0 | 4 | 12 | 5 | 0 | 18 | 3 | 2 | 0 | 0 | 1 | 15 | 6 | 2 | 3 | 0 | 1 | 19 | 15 | 5 | 9940.00 |
| Internav 123 | 0 | 19 | 1 | 2 | 0 | 21 | 1 | 0 | 0 | 0 | 1 | 20 | 2 | 0 | 1 | 0 | 1 | 22 | 20 | 1 | 3.02 |
| Decca DL91 | 1 | 7 | 3 | 11 | 0 | 18 | 4 | 0 | 1 | 1 | 2 | 4 | 18 | 2 | 1 | 0 | 15 | 9 | 4 | 5 | 2.99 |
| S.R.D.(c) | 7 | 4 | 4 | 6 | 1 | 17 | 5 | 0 | 0 | 0 | 5 | 13 | 9 | 3 | 0 | 0 | 6 | 17 | 13 | 3 | 3.17 |
| T.I.9000a | 1 | 2 | 2 | 17 | 0 | 16 | 6 | 2 | 3 | 0 | 1 | 5 | 17 | 3 | 3 | 0 | 11 | 9 | 2 | 11 | 22.00 |
| All Receivers | 9 | 36 | 22 | 41 | 1 | 90 | 19 | 4 | 4 | 1 | 10 | 57 | 52 | 10 | 8 | 0 | 34 | 76 | 54 | 25 | 110.00 |

Time Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|-------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 13.23 | 3.64 | 0.00 | 0.00 | 0.18 | 0.08 | 0.55 | 0.11 | 0.23 | 0.09 | 0.00 | 0.00 |
| Internav 123 | 9.09 | 3.02 | 0.00 | 0.00 | 0.86 | 0.07 | 0.05 | 0.05 | 0.09 | 0.06 | 0.00 | 0.00 |
| Decca DL91 | 12.23 | 3.50 | 0.05 | 0.05 | 0.32 | 0.10 | 0.14 | 0.07 | 0.50 | 0.11 | 0.00 | 0.00 |
| S.R.D.(c) | 11.27 | 3.36 | 0.32 | 0.10 | 0.18 | 0.08 | 0.18 | 0.08 | 0.27 | 0.10 | 0.05 | 0.05 |
| T.I.9000a | 17.59 | 4.19 | 0.05 | 0.05 | 0.09 | 0.06 | 0.09 | 0.06 | 0.77 | 0.09 | 0.00 | 0.00 |
| All Receivers | 12.68 | 3.56 | 0.08 | 0.03 | 0.33 | 0.04 | 0.20 | 0.04 | 0.37 | 0.05 | 0.01 | 0.01 |

X-secondary Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 0.82 | 0.08 | 0.14 | 0.07 | 0.09 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.05 |
| Internav 123 | 0.95 | 0.05 | 0.05 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.05 |
| Decca DL91 | 0.82 | 0.08 | 0.18 | 0.08 | 0.00 | 0.00 | 0.05 | 0.05 | 0.05 | 0.05 | 0.09 | 0.06 |
| S.R.D.(c) | 0.77 | 0.09 | 0.23 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 | 0.09 |
| T.I.9000a | 0.73 | 0.10 | 0.27 | 0.10 | 0.09 | 0.06 | 0.14 | 0.07 | 0.00 | 0.00 | 0.05 | 0.05 |
| All Receivers | 0.82 | 0.04 | 0.17 | 0.04 | 0.04 | 0.02 | 0.04 | 0.02 | 0.01 | 0.01 | 0.09 | 0.03 |

Y-secondary Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 0.68 | 0.10 | 0.27 | 0.10 | 0.09 | 0.06 | 0.14 | 0.07 | 0.00 | 0.00 | 0.05 | 0.05 |
| Internav 123 | 0.91 | 0.06 | 0.09 | 0.06 | 0.00 | 0.00 | 0.05 | 0.05 | 0.00 | 0.00 | 0.05 | 0.05 |
| Decca DL91 | 0.18 | 0.08 | 0.82 | 0.08 | 0.09 | 0.06 | 0.05 | 0.05 | 0.00 | 0.00 | 0.68 | 0.10 |
| S.R.D.(c) | 0.59 | 0.11 | 0.41 | 0.11 | 0.14 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.27 | 0.10 |
| T.I.9000e | 0.23 | 0.09 | 0.77 | 0.09 | 0.14 | 0.07 | 0.14 | 0.07 | 0.00 | 0.00 | 0.50 | 0.11 |
| All Receivers | 0.52 | 0.05 | 0.47 | 0.05 | 0.09 | 0.03 | 0.07 | 0.02 | 0.00 | 0.00 | 0.31 | 0.04 |

Track & Total Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 |
|---------------|------|------|------|------|------|------|
| Internav 204 | 0.86 | 0.07 | 0.68 | 0.10 | 0.23 | 0.09 |
| Internav 123 | 1.00 | 0.00 | 0.91 | 0.06 | 0.05 | 0.05 |
| Decca EL91 | 0.41 | 0.11 | 0.18 | 0.08 | 0.23 | 0.09 |
| S.R.D.(c) | 0.77 | 0.09 | 0.59 | 0.11 | 0.14 | 0.07 |
| T.I.9000a | 0.41 | 0.11 | 0.09 | 0.06 | 0.50 | 0.11 |
| All Receivers | 0.69 | 0.04 | 0.49 | 0.05 | 0.23 | 0.04 |

U.S. WEST COAST CHAIN - DAY 328

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---------------|---|----|----|----|---|----|----|---|---|----|----|----|----|----|----|----|----|----|----|----|---------|
| Internav 204 | 0 | 3 | 7 | 11 | 0 | 13 | 8 | 4 | 3 | 0 | 1 | 14 | 7 | 1 | 6 | 0 | 0 | 13 | 11 | 9 | 9940.00 |
| Internav 123 | 0 | 16 | 4 | 1 | 0 | 19 | 2 | 0 | 0 | 0 | 2 | 18 | 3 | 1 | 1 | 0 | 1 | 20 | 17 | 2 | 3.00 |
| Decca DL91 | 0 | 1 | 9 | 11 | 0 | 16 | 5 | 0 | 0 | 0 | 5 | 10 | 11 | 0 | 2 | 0 | 9 | 10 | 9 | 2 | 2.98 |
| S.R.D.(c) | 4 | 5 | 5 | 7 | 0 | 16 | 5 | 0 | 0 | 0 | 5 | 13 | 8 | 1 | 4 | 0 | 3 | 15 | 10 | 5 | 3.18 |
| T.I.9000a | 0 | 2 | 0 | 19 | 0 | 12 | 9 | 3 | 1 | 0 | 5 | 7 | 14 | 3 | 2 | 0 | 9 | 8 | 5 | 7 | 22.00 |
| All Receivers | 4 | 27 | 25 | 49 | 0 | 76 | 29 | 7 | 4 | 0 | 18 | 62 | 43 | 6 | 15 | 0 | 22 | 66 | 52 | 25 | 110.00 |

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Time Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|-------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 15.00 | 3.87 | 0.00 | 0.00 | 0.14 | 0.07 | 0.32 | 0.10 | 0.50 | 0.11 | 0.00 | 0.00 |
| Internav 123 | 9.09 | 3.02 | 0.00 | 0.00 | 0.73 | 0.10 | 0.18 | 0.08 | 0.05 | 0.05 | 0.00 | 0.00 |
| Decca DL91 | 15.73 | 3.97 | 0.00 | 0.00 | 0.05 | 0.05 | 0.41 | 0.11 | 0.50 | 0.11 | 0.00 | 0.00 |
| S.R.D.(c) | 11.77 | 3.43 | 0.18 | 0.08 | 0.23 | 0.09 | 0.23 | 0.09 | 0.32 | 0.10 | 0.00 | 0.00 |
| T.I.9000a | 18.09 | 4.25 | 0.00 | 0.00 | 0.09 | 0.06 | 0.00 | 0.00 | 0.86 | 0.07 | 0.00 | 0.00 |
| All Receivers | 13.94 | 3.73 | 0.04 | 0.02 | 0.25 | 0.04 | 0.23 | 0.04 | 0.45 | 0.05 | 0.00 | 0.00 |

X-secondary Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 0.59 | 0.11 | 0.36 | 0.10 | 0.18 | 0.08 | 0.14 | 0.07 | 0.00 | 0.00 | 0.05 | 0.05 |
| Internav 123 | 0.86 | 0.07 | 0.09 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.06 |
| Decca DL91 | 0.73 | 0.10 | 0.23 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 | 0.09 |
| S.R.D.(c) | 0.73 | 0.10 | 0.23 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 | 0.09 |
| T.I.9000a | 0.55 | 0.11 | 0.41 | 0.11 | 0.14 | 0.07 | 0.05 | 0.05 | 0.00 | 0.00 | 0.23 | 0.09 |
| All Receivers | 0.69 | 0.04 | 0.26 | 0.04 | 0.06 | 0.02 | 0.04 | 0.02 | 0.00 | 0.00 | 0.16 | 0.04 |

Y-secondary Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 0.64 | 0.10 | 0.32 | 0.10 | 0.05 | 0.05 | 0.27 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 |
| Internav 123 | 0.82 | 0.08 | 0.14 | 0.07 | 0.05 | 0.05 | 0.05 | 0.05 | 0.00 | 0.00 | 0.05 | 0.05 |
| Decca DL91 | 0.45 | 0.11 | 0.50 | 0.11 | 0.00 | 0.00 | 0.09 | 0.06 | 0.00 | 0.00 | 0.41 | 0.11 |
| S.R.D.(c) | 0.59 | 0.11 | 0.36 | 0.10 | 0.05 | 0.05 | 0.18 | 0.08 | 0.00 | 0.00 | 0.14 | 0.07 |
| T.I.9000a | 0.32 | 0.10 | 0.64 | 0.10 | 0.14 | 0.07 | 0.09 | 0.06 | 0.00 | 0.00 | 0.41 | 0.11 |
| All Receivers | 0.56 | 0.05 | 0.39 | 0.05 | 0.05 | 0.02 | 0.14 | 0.03 | 0.00 | 0.00 | 0.20 | 0.04 |

Track & Total Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 |
|---------------|------|------|------|------|------|------|
| Internav 204 | 0.59 | 0.11 | 0.50 | 0.11 | 0.41 | 0.11 |
| Internav 123 | 0.91 | 0.06 | 0.77 | 0.09 | 0.09 | 0.06 |
| Decca DL91 | 0.45 | 0.11 | 0.41 | 0.11 | 0.09 | 0.06 |
| S.R.D.(c) | 0.68 | 0.10 | 0.45 | 0.11 | 0.23 | 0.09 |
| T.I.9000a | 0.36 | 0.10 | 0.23 | 0.09 | 0.32 | 0.10 |
| All Receivers | 0.60 | 0.05 | 0.47 | 0.05 | 0.23 | 0.04 |

U.S. WEST COAST CHAIN - DAY 329

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---------------|---|----|----|----|---|----|----|---|---|----|----|----|----|----|----|----|----|----|----|----|---------|
| Internav 204 | 0 | 4 | 12 | 5 | 0 | 18 | 3 | 1 | 1 | 0 | 1 | 14 | 7 | 1 | 2 | 1 | 3 | 15 | 14 | 4 | 9940.00 |
| Internav 123 | 1 | 21 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 21 | 1 | 0 | 0 | 0 | 1 | 21 | 21 | 0 | 3.00 |
| Decca DL91 | 0 | 8 | 9 | 5 | 0 | 18 | 4 | 2 | 0 | 0 | 2 | 12 | 10 | 2 | 0 | 0 | 8 | 12 | 11 | 4 | 3.03 |
| S.R.D.(c) | 6 | 4 | 8 | 4 | 0 | 18 | 4 | 1 | 0 | 1 | 2 | 15 | 7 | 1 | 1 | 0 | 5 | 17 | 14 | 3 | 3.15 |
| T.I. 9000a | 0 | 2 | 3 | 17 | 0 | 11 | 11 | 1 | 6 | 0 | 4 | 6 | 16 | 0 | 3 | 0 | 13 | 7 | 3 | 9 | 22.00 |
| All Receivers | 7 | 39 | 32 | 31 | 0 | 87 | 22 | 5 | 7 | 1 | 9 | 68 | 41 | 4 | 6 | 1 | 30 | 72 | 63 | 20 | 110.00 |

Time Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|-------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 13.45 | 3.67 | 0.00 | 0.00 | 0.18 | 0.08 | 0.55 | 0.11 | 0.23 | 0.09 | 0.00 | 0.00 |
| Internav 123 | 8.18 | 2.86 | 0.05 | 0.05 | 0.95 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Decca LL91 | 13.36 | 3.66 | 0.00 | 0.00 | 0.36 | 0.10 | 0.41 | 0.11 | 0.23 | 0.09 | 0.00 | 0.00 |
| S.R.D.(c) | 11.55 | 3.40 | 0.27 | 0.10 | 0.18 | 0.08 | 0.36 | 0.10 | 0.18 | 0.08 | 0.00 | 0.00 |
| T.I. 9000a | 17.95 | 4.24 | 0.00 | 0.00 | 0.09 | 0.06 | 0.14 | 0.07 | 0.77 | 0.09 | 0.00 | 0.00 |
| All Receivers | 12.90 | 3.59 | 0.06 | 0.02 | 0.35 | 0.05 | 0.29 | 0.04 | 0.28 | 0.04 | 0.00 | 0.00 |

X-secondary Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 0.82 | 0.08 | 0.14 | 0.07 | 0.05 | 0.05 | 0.05 | 0.05 | 0.00 | 0.00 | 0.05 | 0.05 |
| Internav 123 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Decca DL91 | 0.82 | 0.08 | 0.18 | 0.08 | 0.09 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.06 |
| S.R.D.(c) | 0.82 | 0.08 | 0.18 | 0.08 | 0.05 | 0.05 | 0.00 | 0.00 | 0.05 | 0.05 | 0.09 | 0.06 |
| T.I.9000a | 0.50 | 0.11 | 0.50 | 0.11 | 0.05 | 0.05 | 0.27 | 0.10 | 0.00 | 0.00 | 0.18 | 0.08 |
| All Receivers | 0.79 | 0.04 | 0.20 | 0.04 | 0.05 | 0.02 | 0.06 | 0.02 | 0.01 | 0.01 | 0.08 | 0.03 |

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Y-secondary Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Internav 204 | 0.64 | 0.10 | 0.32 | 0.10 | 0.05 | 0.05 | 0.09 | 0.06 | 0.05 | 0.05 | 0.14 | 0.07 |
| Internav 123 | 0.95 | 0.05 | 0.05 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.05 |
| Decca DL91 | 0.55 | 0.11 | 0.45 | 0.11 | 0.09 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.36 | 0.10 |
| S.R.D.(c) | 0.68 | 0.10 | 0.32 | 0.10 | 0.05 | 0.05 | 0.05 | 0.05 | 0.00 | 0.00 | 0.23 | 0.09 |
| T.I.9000a | 0.27 | 0.10 | 0.73 | 0.10 | 0.00 | 0.00 | 0.14 | 0.07 | 0.00 | 0.00 | 0.59 | 0.11 |
| All Receivers | 0.62 | 0.05 | 0.37 | 0.05 | 0.04 | 0.02 | 0.05 | 0.02 | 0.01 | 0.01 | 0.27 | 0.04 |

Track & Total Statistics

| Column # | 1 | 2 | 3 | 4 | 5 | 6 |
|---------------|------|------|------|------|------|------|
| Internav 204 | 0.68 | 0.10 | 0.64 | 0.10 | 0.18 | 0.08 |
| Internav 123 | 0.95 | 0.05 | 0.95 | 0.05 | 0.00 | 0.00 |
| Decca DL91 | 0.55 | 0.11 | 0.50 | 0.11 | 0.18 | 0.08 |
| S.R.D.(c) | 0.77 | 0.09 | 0.64 | 0.10 | 0.14 | 0.07 |
| T.I.9000a | 0.32 | 0.10 | 0.14 | 0.07 | 0.41 | 0.11 |
| All Receivers | 0.65 | 0.05 | 0.57 | 0.05 | 0.18 | 0.04 |

APPENDIX #6

LORAN-C SIGNAL QUALITY DATA FOR JUAN de FUCA STRAIT

COLLECTED IN U.S. (N.O.A.A.) SHIP McARTHUR

September 1978

Figures

| | | |
|-----|---------|--------------|
| A - | 59900-X | Gain |
| B - | 59900-X | Cycle Number |
| C - | 99400-M | Gain |
| D - | 99400-M | Cycle Number |
| E - | 99400-W | Cycle Number |
| F - | 99400-X | Cycle Number |

Juan de Fuca Strait Loran-C Signal Quality Data

Introduction

The United States Coast Guard and the National Ocean Survey made a Loran-C chart lattice calibration in the U.S. (N.O.A.A.) Ship *McArthur* (Cmdr. Jeffries) in Juan de Fuca Strait in early September 1978. The Loran-C lattice on chart 18400 for the U.S. West Coast Chain was calibrated to improve the accuracy for navigation and regulatory use. The Canadian Hydrographic Service participated in the operations in *McArthur*. An uncalibrated Austron 5000 Loran-C monitor receiver was placed in *McArthur* and gain, cycle and noise information was logged at the approaches to and within Juan de Fuca Strait for both the Canadian and the U.S. West Coast Chains. The Canadian Coast Guard and the Canadian Hydrographic Service provided logistics support when deploying Miniranger III precise positioning transponder stations on Vancouver Island.

Data

West Canadian Chain, X-Secondary (Shoal Cove)

Figures A and B show the gain and cycle data for the X-Secondary transmission in Juan de Fuca Strait. Receiver gain is extremely high within Juan de Fuca, but falls appreciably as the observer moves away from the land, implying a recovery in field strength as the signal moves offshore. Cycle numbers observed vary from 2.75 to 3.29. The data outside Cape Flattery was collected on a fine day. The data within the strait was obtained under drizzly conditions.

U.S. West Coast Chain, Master (Fallon)

The gain numbers, for the 9940-Master transmission, which are shown in Figure C, are appreciably higher within Juan de Fuca Strait than outside Cape Flattery. It is possible some topographic affect on propagation overcomes direct attenuation with distance. The cycle number for the Fallon transmission ranges from 2.98 to 3.30 in this area. It appears also to display some underlying topographic effect since the cycle number decreases offshore. However most of the variation can be associated with change in the weather during the period of observations.

U.S. West Coast Chain, W-Secondary (George)

The cycle number for the George transmission has the predictably small range that is associated with a good strong signal (see Figure E). An interesting effect is the apparent decrease in cycle number in the centre of Juan de Fuca Strait and the increase in the number adjacent to the shore. It is possible that the increase in cycle number off Cape Alava is due to the topographic effect of the Olympic Mountains.

U.S. West Coast Chain, X-Secondary (Middleton)

The cycle number for the Middleton transmission of the U.S. West Coast Chain is shown in Figure F. It appears that any spatial pattern for this cycle number could also be associated with weather or time of day. The cycle number ranges from 3.02 to 3.23.

Discussion

Cycle numbers for each transmission are controlled from the transmitters within very close tolerances. For the most part, changes in cycle number shown on the diagrams are much larger than any variations due to changes in E.C.D. at the transmitters. Therefore, any changes in observed cycle numbers can be attributed to,

- 1) measurement error which is about ± 0.05 (± 5 microseconds),
- 2) spatial propagation changes, and,
- 3) weather or noise level changes.

It is difficult to isolate spatial and temporal effects with one set of observations for the Straits of Juan de Fuca. However, it is interesting to note two points:

- 1) The large range of the cycle number for the Middleton, Fallon and Shoal Cove transmissions; and,
- 2) The possibility of some detectable topographic effects on Loran-C signal propagation in this area.

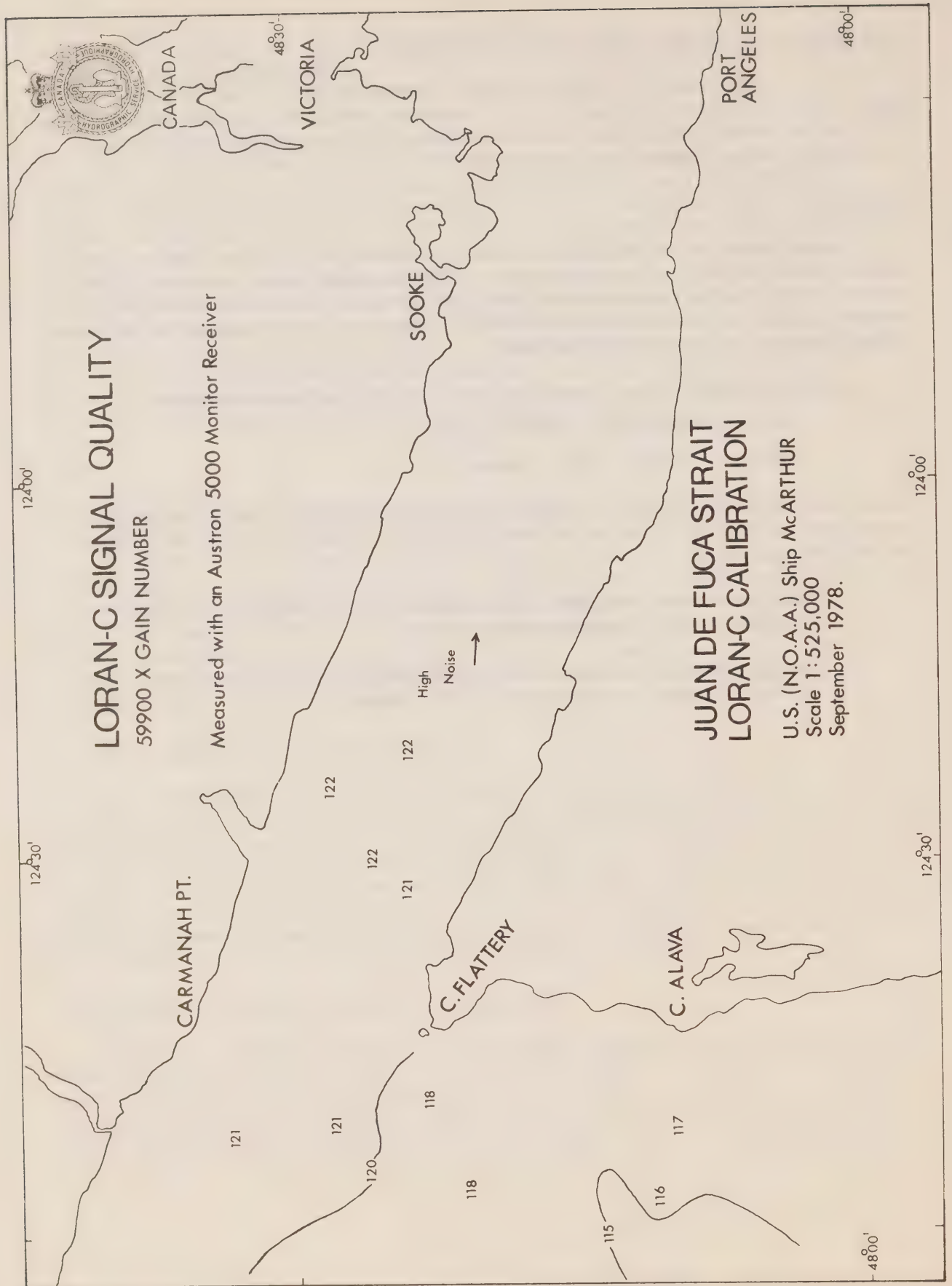


FIGURE A.

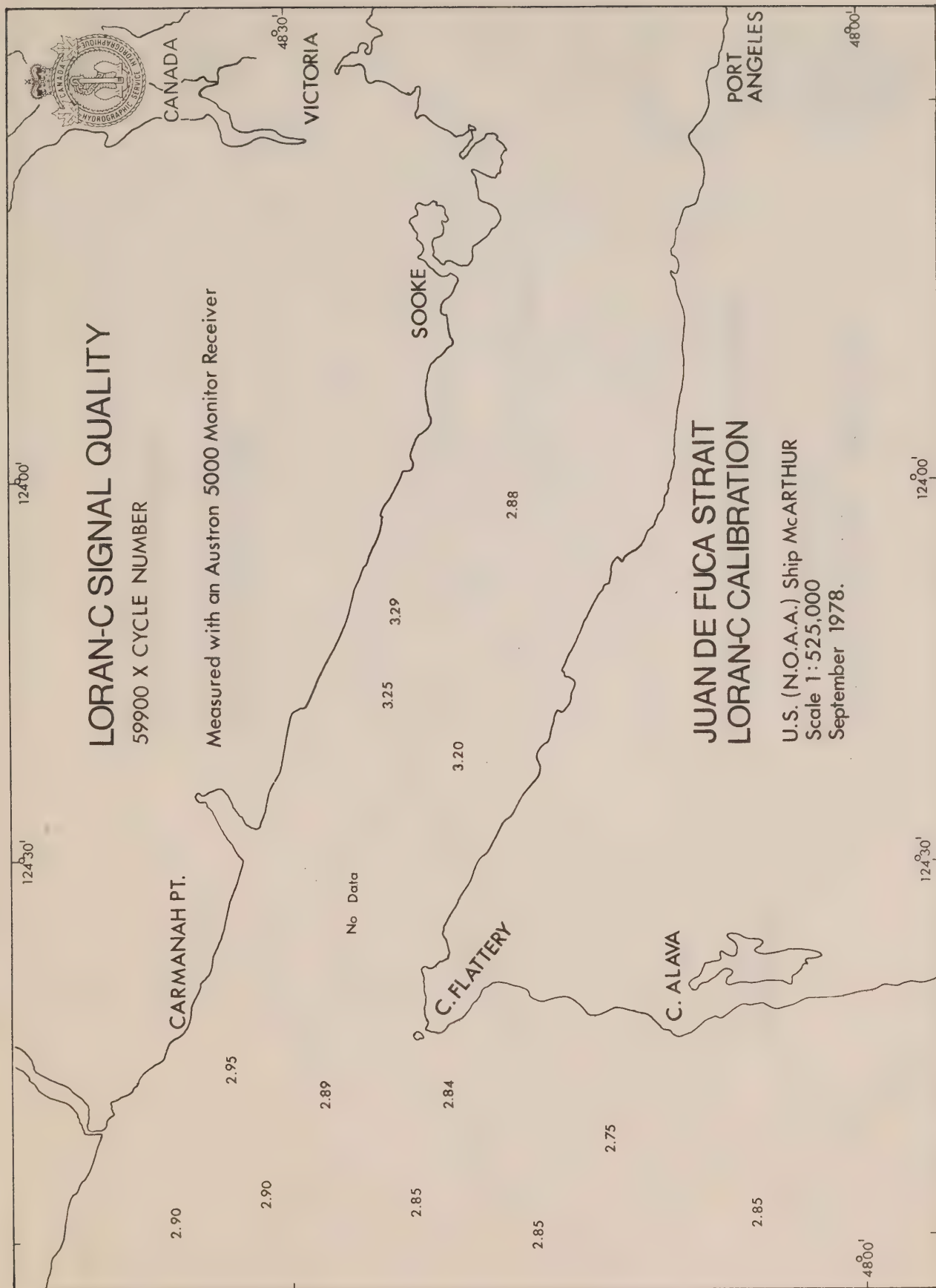


FIGURE B.

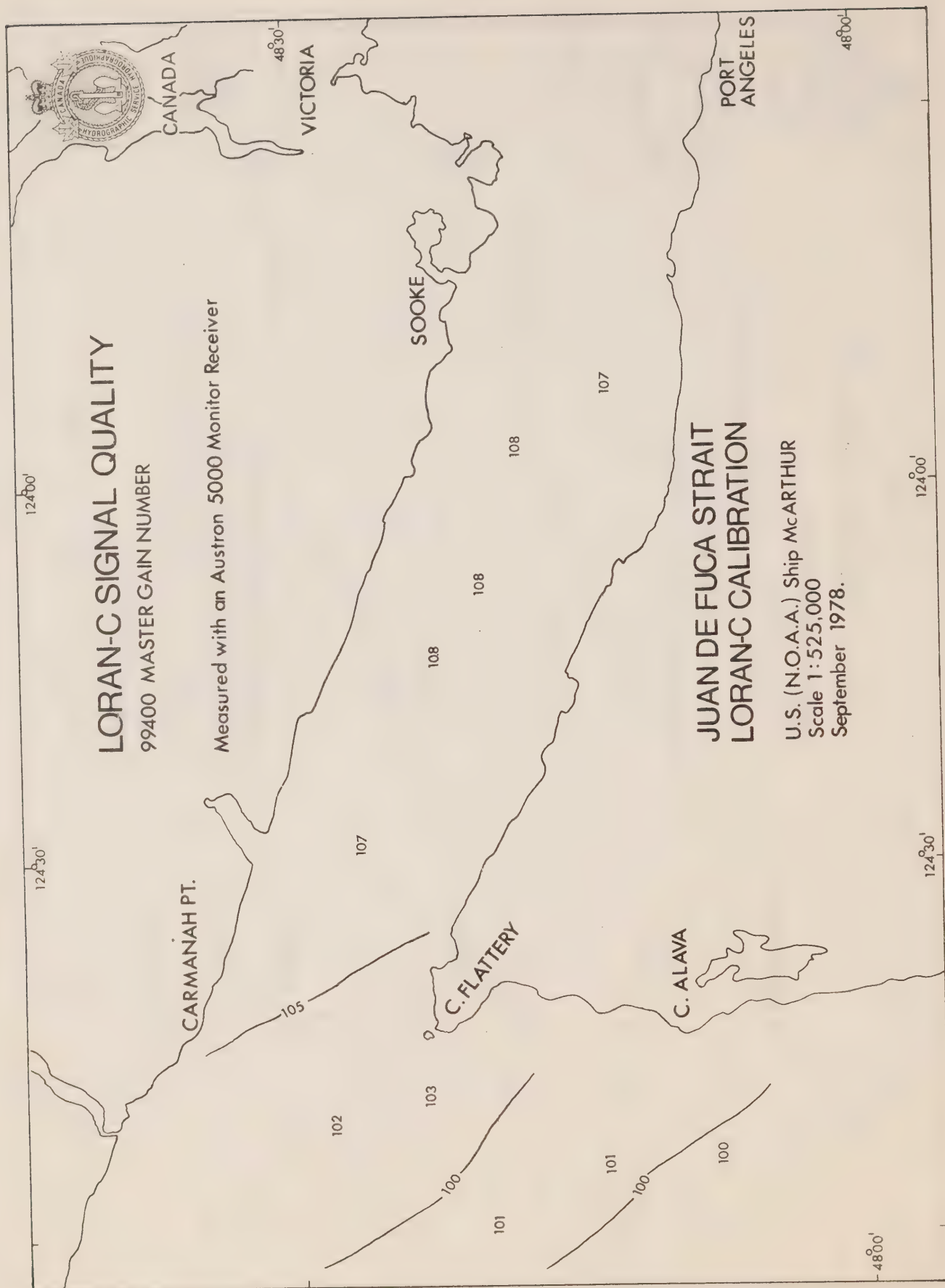


FIGURE C.

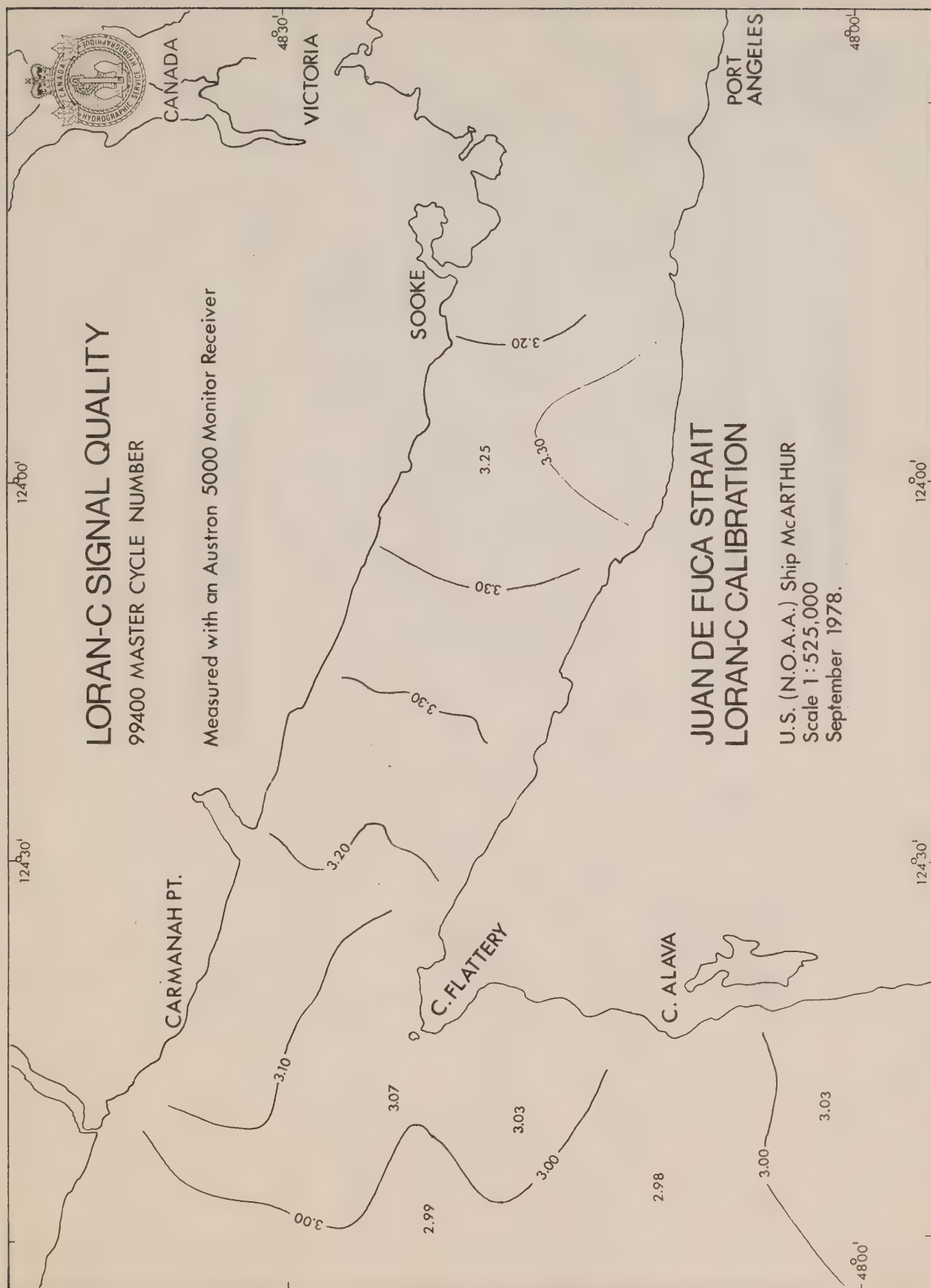


FIGURE D.

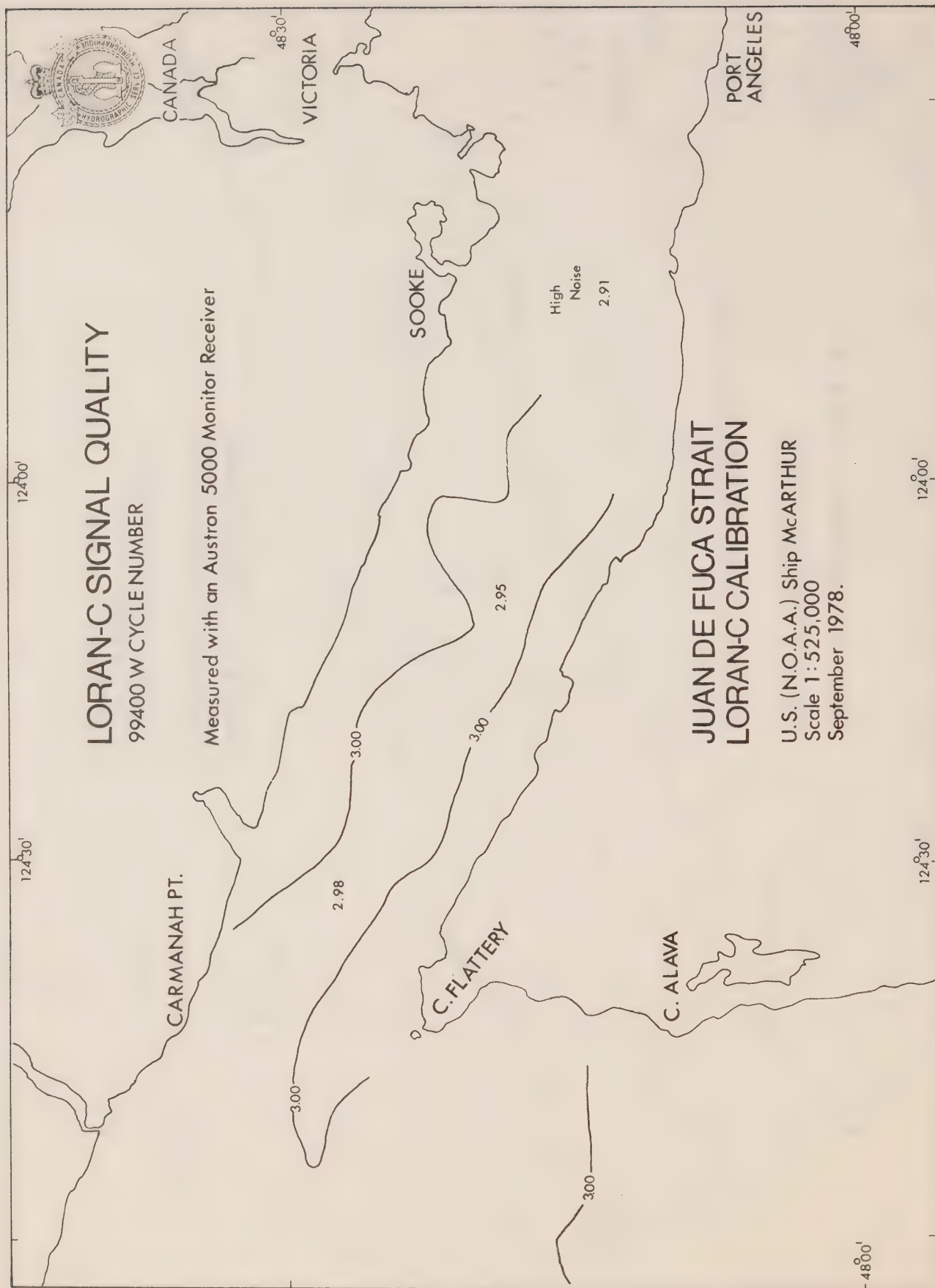


FIGURE E

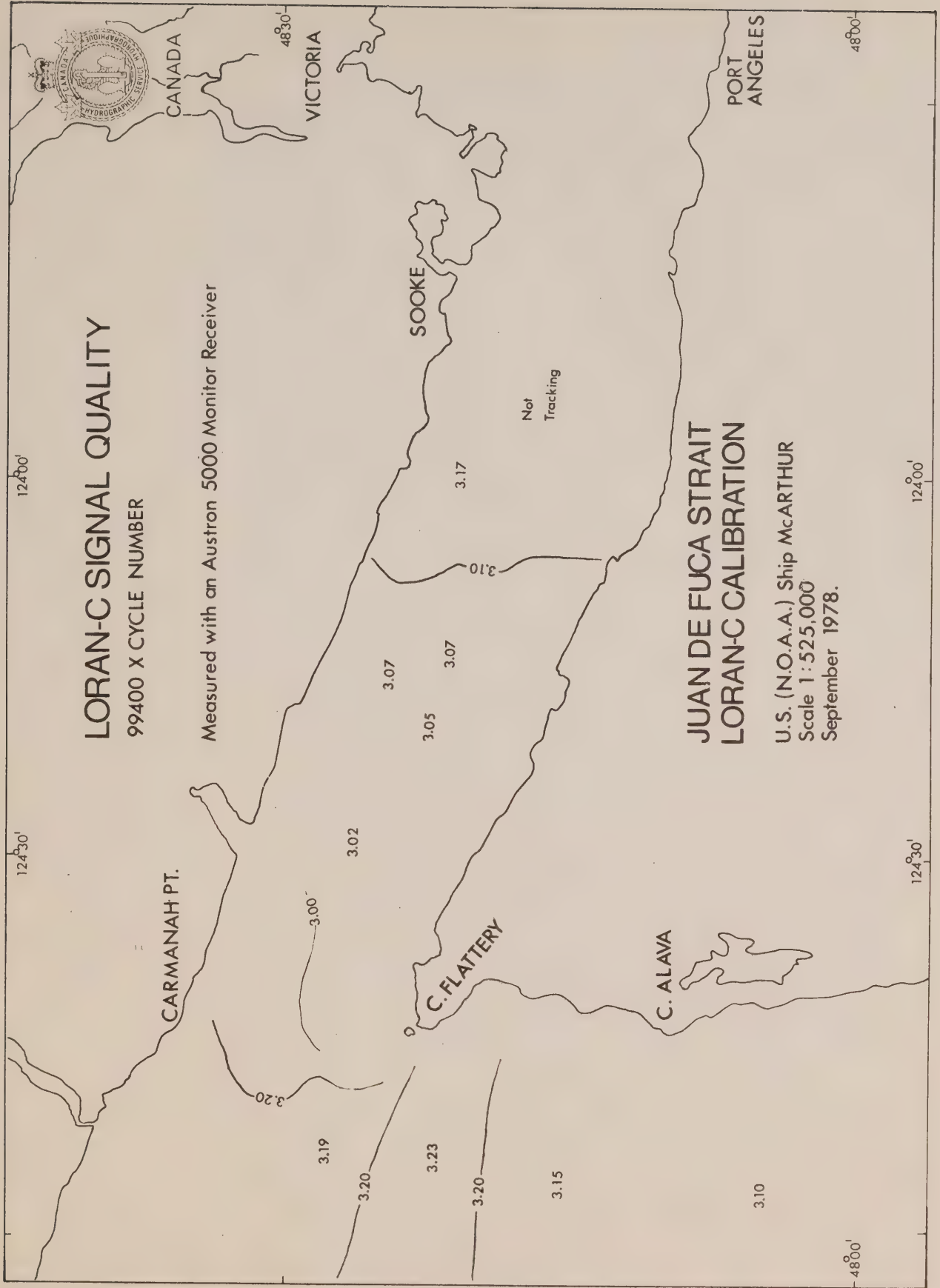


FIGURE F.

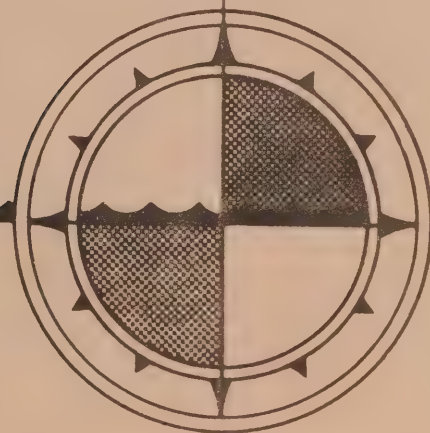
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**DISTRIBUTION OF AQUATIC OLIGOCHAETA
IN SOME HABITATS OF
LOWER BRITISH COLUMBIA**

by
R.O. Brinkhurst



**INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY
Sidney, B.C.**



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DISTRIBUTION OF AQUATIC OLIGOCHAETA
IN SOME HABITATS OF LOWER
BRITISH COLUMBIA

by

R.O. Brinkhurst

Institute of Ocean Sciences, Patricia Bay
Sidney, B.C.

1979

This is a manuscript which has received only limited circulation. On citing this report in a bibliography, the title should be followed by the words "UNPUBLISHED MANUSCRIPT" which is in accordance with accepted bibliographic custom.

ABSTRACT

The distribution of aquatic oligochaeta in some habitats
of lower British Columbia.

INTRODUCTION

Aquatic oligochaeta have been collected around the Saanich peninsula and Victoria by the author and various students and assistants, including M. Austin, H.R. Baker, W. Carolsfeld, and P. Chapman. Other collections were donated by K. Coates and C. Levings and T. Northcote. Some of these were identified under contract by C. Low and some of the assistants listed above. The taxonomic findings have been documented elsewhere (Brinkhurst 1976, 1978, Brinkhurst and Baker 1979) but the more detailed distribution records may be of use in pollution surveys and so are set out here.

Each collection is dealt with separately, with appropriate reference to more general ecological reports where they exist.

DISTRIBUTION OF OLIGOCHAETA

1. The freshwater systems of Greater Victoria.

Most of this sampling was carried out by W. Carolsfeld in cooperation with R. Langford (Aqua Sciences Consulting, Victoria). Collecting stations are illustrated in Figure 1, species distributions are indicated in Table 1.

These streams are dominated by pollution tolerant forms, stations 9 and 14 lacking other fauna altogether. Only at station 1 was there much sign of a reasonably diverse fauna of oligochaetes.

2. Samples from the Victoria Harbour system and Esquimalt Lagoon. H.R. Baker.

Sampling stations are illustrated on Fig. 1, numbers 24 on. The identifications are listed in Table 2.

Some species in this collection are restricted to the innermost portion of the Gorge (T. apectinatus, T. nerthoides, L. monothecus) but T. pseudogaster ranges further and L. verrucosus and L. victoriensis are found more or less throughout Victoria Harbour and the Gorge. The collection in Esquimalt Lagoon was disappointing.

3. Samples from five local lakes in Victoria. W. Carolsfeld, M. Austin.

Four of the lakes sampled are illustrated in Fig. 1. The species found were:

Jan. 12, 1977. Elk Lake (El) L. hoffmeisteri - abundant
? I. templetoni (immature)

Beaver Lake (Bl-3) S. lacustris, N. communis/variabilis
D. digitata ? I. templetoni

Swan Lake (Sl) N. communis/variabilis - only 1 specimen.
The lake is downstream of polluted station 14.

Prospect Lake (Pl-2) L. hoffmeisteri, L. profundicola,
I. templetoni, S. lacustris, ? D. digitata.

Shawnigan Lake B. vej dovskyanum, A. pigueti, N. communis/variabilis, Telmalodrilus sp.

4. Samples from the Saanich peninsula: W. Carolsfeld.

Identifications are listed in Table 3, the locations are shown in Fig. 2.

The more interesting findings are those of the species thought to be spread by man from the tropics (B. sowerbyi) in the shallow eutrophic bay of Prospect Lake (1), and the interesting assemblage in the Airport Creek (6,7), which includes one record new for N. America (R. falciformis). Stations 3-5, 9 and 10 show every sign of organic pollution, that at the last two having been related to the Airport sewage discharge which is now connected to the S.D.W.* at Sidney. Stations 11-12 support three brackish water species in a creek submerged at highest tides.

5. Marine collection sites around Saanich peninsula. H.R. Baker.

Identifications are listed in Table 4, stations are shown in Fig. 2 (14 on).

The collections resemble those in Victoria Harbour.

6. Collections listed in Levings et al. (1975) from B.C. estuaries, identified by C. Low.

The oligochaetes were found in Porpoise Harbour, adjacent to the Skeena River estuary. The sites were identified by Levings et al. (1975, Fig. 10).

Identifications were as follows: Paranais litoralis and Tubificoides gabriellae were abundant, and were found at G4, G5 and quadrats 1-4, 7 and 8 as well as two other samples (label illegible). Monopylephorus irroratus was found at quadrat 2-3 and M. pacificus at quadrat 4.

7. Collections listed by Levings and Coustalin (1975) from the banks in the Fraser River delta.

The distribution of the three naidids and one tubificid found in plankton tows taken over Sturgeon Bank at high tide is shown in Fig. 3. The distribution of species observed in benthic samples is shown in Fig. 4. Most of the specimens of the naidids P. litoralis and P. frici and the tubificid T. gabriellae overlap, and these are concentrated mostly on either side of the Iona Island jetty and sewage outfall and the two jetties at Tsawwassen. The tubificid has the widest distribution, P. frici the narrowest. This same assemblage is found in the North Arm of the Fraser River until a point is reached at which the freshwater T. tubifex and L. hoffmeisteri replace them. The location of this change in fauna shifts seasonally in response to the volume of freshwater in the river.

8. Marine coastline collections by K. Coates.

As these collections cover a wide geographic area, collection sites will be identified by map coordinates, the names being the nearest appropriate. Details are given in Table 5. No ecological inferences can be drawn from these observations.

* Sewage Disposal Works

9. Collections from the Fraser River by Northcote et al. (1976) identified by P. Chapman and W. Carolsfeld.

Samples were obtained on four dates at fourteen stations from the seaward end of each of the four main channels (stations 1-4) to below Hope (14). All worms were examined unless there were more than 200 in a sample, at which point the first 200 were counted (Tables 6-9). The numbers on the tables refer to the sum of all replicates, the number of replicates examined by us being indicated.

The August/September 1973 survey clearly shows the separation of the system into three sets of stations, 1-4 brackish water, 5-9 with several species of tubificids (with the largest numbers at 5) and the "upland" system above 9, which is above the influence of Vancouver. The presence of freshwater species at 1-4 at other times suggested the possibility of seasonal shifts in the fauna in relation to the seasonal river flow pattern that has now been borne out and will be reported elsewhere.

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FIGURE LEGENDS

- Figure 1. Collecting stations in Greater Victoria, B.C.
See data on Tables 1-2.
- Figure 2. Collecting stations on the Saanich peninsula , Vancouver Island.
See data on Tables 3-4.
- Figure 3. Distribution of species in drift samples taken around the mouth of the North Arm, Fraser River, Vancouver, B.C. (from Levings and Coustalin 1975).
- Figure 4. Distribution of species on the delta of the Fraser River, Vancouver, B.C. (from Levings and Coustalin 1975).

Table 2. Distribution of marine species of oligochaetes at stations identified in Fig.1 (24 on).

| Station | Tubificidae | | | | | | | Naididae | |
|---------|--|----------------------|------------------------|-----------------------|----------------------|------------------------|----------------------|-------------------|---------------------|
| | <u>T. gabriellae</u> | <u>T. nerthoides</u> | <u>T. pseudogaster</u> | <u>T. apectinatus</u> | <u>L. verrucosus</u> | <u>L. victoriensis</u> | <u>L. monothecus</u> | <u>L. frantzi</u> | <u>P. litoralis</u> |
| 24 | [all <u>Capitella capitata</u> (polychaete)] | | | | | | | | |
| 25 | | | | | | | | | 93 |
| 26 | | 2 | | 1 | | | | | |
| 27 | 6 | | ? | 1 | 1 <u>L. sp.?</u> | | | | |
| 28 | | | | | 1 | 3 | 6 | | |
| 29 | | | ? | | 3 <u>L. sp.?</u> | | | | |
| 30 | | 1 | 3 | 2 | 16 | 51 | 92 | | |
| 31 | | 15 | | | 9 | 11 | 12 | 2 | |
| 32 | | | ?2 | | | | | | |
| 33 | | | ? | | 3 <u>L. sp.?</u> | | | | 43 |
| 34 | | | 6 | | 4 | | | | |
| 35 | | | | | 1 | 1? | | | |
| 36 | | | | | | | | | |
| 37 | | | 3 | | 6 | | | | |
| 38 | | | 4 | | 76 | | | | |
| 39 | | | 1 | | 40 | 1 | | | |
| 40 | | | 3 | | 6 | | | | |
| 41 | | | 16 | | 27 | | | | |
| 42 | | | | | 10 | | | | |
| 43 | | | | | 1 | 1 | | | |
| 44 | | | | | 2 | | | | |
| 45 | | | | | | 3 | | | |
| 46 | | | | | 80 | 2 | | | |
| 47 | | | | | ?1 | 3 | 4 | | |

Table 4. Distribution of marine species of Oligochaetes at stations illustrated in Fig.2 (14 on)

| Station | Tubificidae | | |
|---------|------------------------|----------------------|----------------------|
| | <u>L. victoriensis</u> | <u>L. verrucosus</u> | <u>L. monothecus</u> |
| 14 | 5 | 1 | - |
| 15 | 15 | 1 | - |
| 16 | 64 | 24 | 1 |
| 17 | 22 | 146 | - |
| 18 | 14 | 8 | - |
| 19 | - | 5 | - |

Table 5. Marine species collected around Vancouver Island by K. Coates

| Location | Longitude | Latitude | Date 1976 | Species | | | | | | | | |
|----------------|-------------|------------|--------------|------------------------------|-------------------------------|---------------------------------|-------------------------------|-------------------------------|----------------------------------|--------------------------------|-----------------------------------|--------------------------------|
| | | | | <u>T.</u> <u>coatesae</u> | <u>T.</u> <u>gabrielae</u> | <u>M.</u> <u>rubroniveus</u> | <u>M.</u> <u>irroratus</u> | <u>M.</u> <u>pacificus</u> | <u>M.</u> <u>longisetosus</u> | <u>L.</u> <u>verrucosus</u> | <u>L.</u> <u>victoriensis+</u> | <u>L.</u> <u>monothecus</u> |
| Burrard 3 | 123°07.59'W | 49°18.22'N | 21/11 | | | | | | | 1 | 1 | |
| 4 | " .52' | " " .19' | " | | | | | | | | 14 | |
| 7 | " .20' | " 17.88' | " | | 25 | | | | | | | |
| 8 | " .17' | " " .83' | " | | | | | | | | 3 | |
| 9 | " .12' | " " .83' | " | | | | | | ++ | | | |
| 10 | " .06' | " " .90' | 22/11 | | | | | | 1 | | | |
| 11 | " .05' | " " .86' | " | | | | | | 1 | 1 | | |
| Moyeha River 2 | 125°54.39' | 49°25.09' | 27/7 | | | | | 9 | | | | |
| Port Alice 1 | 127°27.33' | 50°23.25' | 13/6 | | | | | + | | | | |
| 4 | " " .77' | " 22.81' | " | | 3 | | | | | | | |
| 5 | " 28.11' | " 23.12' | " | | | | | + | | | | |
| 10 | " " .42' | " " .87' | " | | | | | + | | | | |
| Patricia Bay 1 | 123°26.09' | 48°39.03' | 24/5 | | | | | | | 1 | | |
| 2 | " " .08' | " " " | | | | | | | | | 1 | |
| 6 | " 27.00' | " " .07' | | | | | | | 1 | | | |
| Ocean Falls 1 | 127°41.10' | 52°21.13' | 26/2 | | | | | | + | | | |
| 4 | " " .67' | " " .24' | | | | | | | + | | | |
| 5 | " " " | " " " | | | | | | | + | | | |
| 6 | " 42.58' | " " .34' | | | | 60 | | | + | | | |
| 8 | " 43.14' | " " .52' | | | | | 3 | | + | | | |
| 9 | " " .12' | " " .53' | | | | | | | + | | | |
| 10 | " " .11' | " " " | | | | | ++ | | + | | | |
| 11 | " " .15' | " " .55' | | | | | | | + | | | |
| 13 | " " .21' | " " " | | | | | | | + | | | |
| Elk Falls 6 | 125°17.50' | 50°04.39' | 17/7 | | | | | + | | | | |
| 7 | " " .48' | " " .30' | " | | | | | + | | | | |
| 15 | " 16.04' | " " .24' | 11/6 | | | | | | + | | | |
| Chemainus 2 | 123°38.05' | 48°53.05' | 1/5 | 1 | | | | | | 10 | | |
| 3 | " 41.07' | " 54.07' | " | 2 | | | | | | | | |
| 5 | " 40.02' | " " .06' | " | 1 | | | | | | | | |
| 8 | " " .04' | " " .45' | " | 12 | | | | | | | | |
| 9 | " 41.08' | " " .07' | 3/5 | 20 | | | | | | + | | |

...Cont'd.

Table 2 (Continued)

| Location | | Longitude | Latitude | Date 1976 | Species | | | | | | | | |
|----------------|---|------------|-----------|--------------|--------------------|----------------------|-----------------------|---------------------|---------------------|------------------------|----------------------|-------------------------------------|----------------------|
| | | | | | <u>T. coatesae</u> | <u>T. gabriellae</u> | <u>M. rubroniveus</u> | <u>M. irroratus</u> | <u>M. pacificus</u> | <u>M. longisetosus</u> | <u>L. verrucosus</u> | <u>L. victoriensis</u> ⁺ | <u>L. monothecus</u> |
| Portage Inlet | 2 | 123°24.00' | 48°28.00' | 8/1 | | | | + | | | | | |
| | 4 | " 21.00' | " " " ' | 11/1 | | | ? | + | | | | | |
| Prince Rupert | 1 | 130°16.04' | 54°14.51' | 1/9 | | | ? | | | | | | |
| | 2 | " " " | " " .55' | " | | | | | | | | | ? |
| | 3 | " 17.01' | " " .43' | " | | | + | + | | | | | |
| | 4 | " " " | " " .48' | " | | | + | + | | | | | |
| | 5 | " " .22' | " 12.89 | " | | | ? | | | | | | |
| Powell River | | 124°32.83' | 49°51.57' | 17/7 | | | + | + | | | | | |
| Tsehum Harbour | | 123°25.00' | 49°40.00' | 2/2 | | | | | | | | | + |
| Johnson Str* | | 126°36.- | 50°30.01' | 11/7 | | | | | | | | | 1 |

* 451 m - D.V. Ellis coll.

+ also known from Alberni Canal near dumpsite (Dobrocky Seatech)
Aug. 1 1978, 48M.

Table 6. Distribution of aquatic oligochaetes in the lower Fraser River
September/October 1972

| Station | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|------------------------------|-----|-----|-----|----|-----|---|---|---|---|----|----|----|----|----|
| # replicates | 4 | 2 | 4 | 2 | 2 | 1 | 1 | 0 | 2 | 0 | 0 | 1 | 1 | 0 |
| Species | | | | | | | | | | | | | | |
| LUMBRICULIDAE | | | | | | | | | | | | | | |
| <u>K. hexatheca</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>S. heringianus</u> | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| NAIDIDAE | | | | | | | | | | | | | | |
| <u>S. fraseri</u> | - | - | 1 | - | 21 | - | 7 | - | 7 | - | - | 13 | 13 | - |
| <u>V. comata</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>P. frici</u> | 22 | 64 | 25 | - | 6 | - | - | - | - | - | - | - | - | - |
| <u>P. litoralis</u> | 6 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>N. behningi</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>N. elinguis</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>N. communis</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>S. appendiculata</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| TUBIFICIDAE | | | | | | | | | | | | | | |
| <u>L. hoffmeisteri</u> | - | - | 37 | 67 | 16 | - | 1 | - | - | - | - | - | - | - |
| <u>L. profundicola</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>L. claparedeianus</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>L. udekemianus</u> | - | 24 | 7 | 2 | 7 | - | 1 | - | - | - | - | - | - | - |
| <u>T. tubifex</u> | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| <u>I. frantzi</u> | - | - | - | - | - | 9 | - | - | - | - | - | - | - | - |
| <u>I. f. capillatus</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>I. mastix</u> | - | 2 | - | - | 54 | - | - | - | 1 | - | - | - | - | - |
| <u>I. templetoni</u> | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - |
| <u>T. gabriellae</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>P. freyi</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>B. vej dovskyanum</u> | - | 13 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| <u>A. pluriseta</u> | - | - | - | - | 5 | - | - | - | - | - | - | - | - | - |
| Immature plus hair setae | 2 | 10 | 3 | 0 | 25 | - | 3 | - | - | - | - | - | - | - |
| Immature minus hair setae | 301 | 325 | 252 | 63 | 122 | - | 8 | - | - | - | - | - | - | - |

Table 7. Distribution of aquatic oligochaetes in the lower Fraser River
November 1972

| Station | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|------------------------------|-----|-----|-----|----|-----|----|----|----|-----|----|----|----|----|----|
| # replicates | 4 | 2 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 1 | 1 | 1 |
| Species | | | | | | | | | | | | | | |
| LUMBRICULIDAE | | | | | | | | | | | | | | |
| <u>K. hexatheca</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>S. heringianus</u> | - | - | - | - | - | 6 | - | - | - | - | - | - | - | - |
| NAIDIDAE | | | | | | | | | | | | | | |
| <u>S. fraseri</u> | 2 | - | - | - | - | - | 85 | 44 | 105 | 5 | - | 5 | 23 | 17 |
| <u>V. comata</u> | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - |
| <u>P. frici</u> | 106 | 7 | - | - | - | - | 9 | - | - | - | - | - | - | - |
| <u>P. litoralis</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>N. behningi</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>N. elinguis</u> | 2 | - | - | - | 1 | - | 3 | - | - | - | - | - | - | - |
| <u>N. communis</u> | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - |
| <u>S. appendiculata</u> | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - |
| TUBIFICIDAE | | | | | | | | | | | | | | |
| <u>L. hoffmeisteri</u> | - | 3 | 2 | - | 8 | - | - | 1 | - | - | - | - | - | - |
| <u>L. profundicola</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>L. claparedeianus</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>L. udekemianus</u> | 60 | 6 | - | - | - | - | 5 | - | - | - | - | - | - | - |
| <u>T. tubifex</u> | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - |
| <u>I. frantzi</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>I. f. capillatus</u> | - | - | - | - | - | 5 | - | - | 9 | - | - | - | - | - |
| <u>I. mastix</u> | - | - | - | - | 10 | 8 | 1 | - | 15 | - | - | - | - | - |
| <u>I. templetoni</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>T. gabriellae</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>P. freyi</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>B. vej dovskyanum</u> | - | - | - | - | - | 15 | - | - | - | - | - | - | - | - |
| <u>A. pluriseta</u> | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - |
| Immature plus hair setae | 3 | 3 | - | - | 3 | 1 | 8 | - | - | 1 | - | - | - | - |
| Immature minus hair setae | 66 | 195 | 525 | 92 | 217 | 58 | 10 | - | 12 | 19 | - | - | 1 | - |

Table 8. Distribution of aquatic oligochaetes in the lower Fraser River
March/April 1973

| Station | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|------------------------------|-----|---|-----|---|-----|----|----|----|----|----|----|----|-----|----|
| # replicates | 2 | 3 | 7 | 0 | 7 | 6 | 7 | 3 | 6 | 7 | 1 | 2 | 2 | 1 |
| Species | | | | | | | | | | | | | | |
| LUMBRICULIDAE | | | | | | | | | | | | | | |
| <u>K. hexatheca</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>S. heringianus</u> | - | - | - | - | 1 | - | 2 | 1 | 1 | 4 | 2 | - | - | 1 |
| NAIDIDAE | | | | | | | | | | | | | | |
| <u>S. fraseri</u> | - | - | - | - | 1 | - | 16 | - | 57 | 43 | 13 | 24 | 164 | - |
| <u>V. comata</u> | 1 | - | - | - | - | - | - | - | - | - | - | - | 1 | - |
| <u>P. frici</u> | 18 | - | 17 | - | 2 | - | - | - | - | - | - | - | - | - |
| <u>P. littoralis</u> | 91 | - | 39 | - | - | - | - | - | - | - | - | - | - | - |
| <u>N. behningi</u> | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - |
| <u>N. elinguis</u> | - | - | - | - | - | - | 1 | - | - | - | - | 1 | - | - |
| <u>N. communis</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>S. appendiculata</u> | - | - | - | - | 2 | - | - | - | - | 2 | - | - | - | - |
| <u>O. serpentina</u> | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - |
| TUBIFICIDAE | | | | | | | | | | | | | | |
| <u>L. hoffmeisteri</u> | - | - | 25 | - | 104 | - | 10 | 7 | - | 2 | - | - | - | - |
| <u>L. profundicola</u> | - | - | - | - | 10 | - | 1 | - | - | - | - | - | - | - |
| <u>L. claparedeianus</u> | - | - | - | - | 1 | - | - | 2 | - | - | - | - | - | - |
| <u>L. udekemianus</u> | - | - | - | - | - | - | 1 | - | - | 1 | - | - | - | - |
| <u>T. tubifex</u> | - | - | - | - | 13 | - | 2 | - | - | - | - | - | - | - |
| <u>I. frantzi</u> | - | - | - | - | - | 3 | - | 14 | - | - | - | - | - | - |
| <u>I. f. capillatus</u> | - | - | - | - | - | 12 | - | 23 | 2 | - | - | - | - | - |
| <u>I. mastix</u> | - | - | - | - | 48 | - | - | 2 | 1 | - | - | - | - | - |
| <u>I. templetoni</u> | - | - | - | - | 9 | - | - | - | - | - | - | - | - | - |
| <u>T. gabriellae</u> | - | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>P. freyi</u> | - | - | - | - | 3 | - | - | - | - | - | - | - | - | - |
| <u>B. vej dovskyanum</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>A. pluriseta</u> | - | - | - | - | 9 | - | - | 1 | - | - | - | - | - | - |
| Immature plus hair setae | - | - | - | - | 55 | - | - | - | - | - | - | - | - | - |
| Immature minus hair setae | 172 | - | 219 | - | 853 | 11 | 52 | 38 | 5 | 2 | - | 1 | - | - |

Table 9. Distribution of aquatic oligochaetes in the lower Fraser River
August/September 1973

| Station | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|------------------------------|-----|----|----|---|-----|-----|-----|----|----|----|----|----|----|----|
| # replicates | 8 | 6 | 3 | 1 | 6 | 6 | 8 | 5 | 6 | 7 | 2 | 2 | 0 | 2 |
| Species | | | | | | | | | | | | | | |
| LUMBRICULIDAE | | | | | | | | | | | | | | |
| <u>K. hexatheca</u> | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - |
| <u>S. heringianus</u> | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - |
| NAIDIDAE | | | | | | | | | | | | | | |
| <u>S. fraseri</u> | - | - | - | - | 41 | 178 | 564 | 19 | 21 | 90 | 19 | 44 | - | 17 |
| <u>V. comata</u> | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - |
| <u>P. frici</u> | 207 | 3 | 31 | - | 59 | 1 | - | - | - | - | - | - | - | - |
| <u>P. litoralis</u> | 41 | - | 8 | 1 | - | - | 1 | - | - | - | - | - | - | - |
| <u>N. behningi</u> | - | - | - | - | - | - | - | 1 | - | 2 | - | - | - | - |
| <u>N. elinguis</u> | - | - | - | - | - | 1 | 1 | - | - | - | - | - | - | - |
| <u>N. communis</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>S. appendiculata</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>D. digitata</u> | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - |
| TUBIFICIDAE | | | | | | | | | | | | | | |
| <u>L. hoffmeisteri</u> | - | - | - | - | 88 | 16 | 2 | - | 4 | - | 2 | - | - | - |
| <u>L. profundicola</u> | - | - | - | - | - | 5 | - | - | 14 | - | - | - | - | - |
| <u>L. clapparedeianus</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>L. udekemianus</u> | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - |
| <u>T. tubifex</u> | - | - | - | - | 31 | - | 2 | - | - | - | - | - | - | - |
| <u>I. frantzi</u> | - | - | - | - | 16 | 13 | 1 | - | - | - | - | - | - | - |
| <u>I. f. capillatus</u> | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - |
| <u>I. mastix</u> | - | - | - | - | 29 | 11 | - | - | 2 | - | - | - | - | - |
| <u>I. templetoni</u> | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>T. gabriellae</u> | 23 | 21 | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>P. freyi</u> | 1 | 4 | - | - | - | - | - | - | - | - | - | - | - | - |
| <u>B. vej dovskyanum</u> | - | - | - | - | 1 | 1 | - | - | - | - | - | - | - | - |
| <u>A. plurisetia</u> | - | - | - | - | 5 | 3 | - | - | 2 | - | - | - | - | - |
| <u>A. limnobius</u> | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - |
| Immature plus hair setae | - | - | - | - | 76 | 9 | 9 | 1 | 3 | - | - | - | - | - |
| Immature minus hair setae | 6 | 1 | - | 2 | 668 | 129 | - | 1 | 14 | 1 | - | - | - | - |

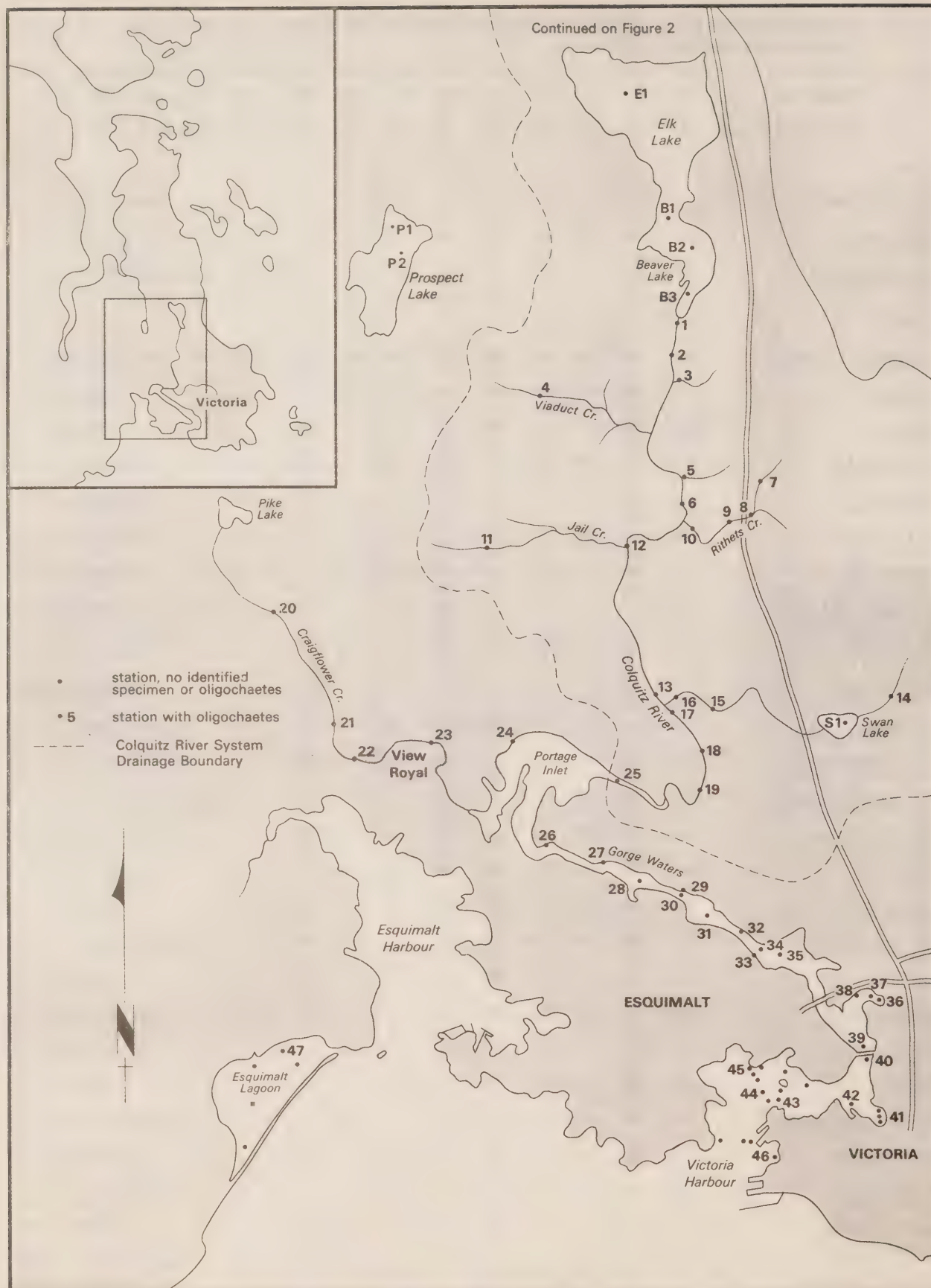


Figure 1 Collecting stations in Greater Victoria, B.C.
 See data on Tables 1-2

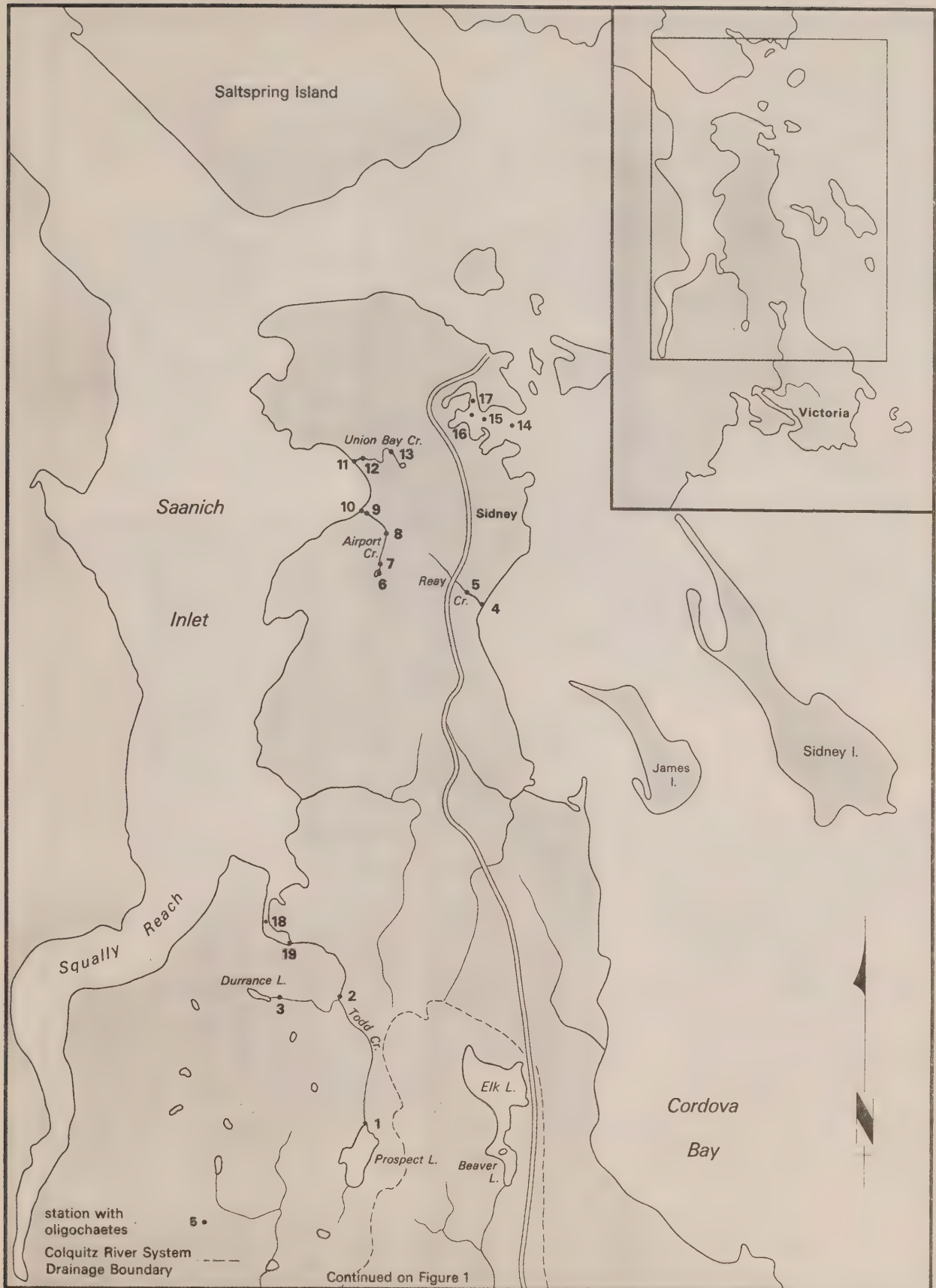


Figure 2 Collecting stations on the Saanich Peninsula, Vancouver Island.
See data on Tables 3-4.



Figure 3 Distribution of species in drift samples taken around the mouth of the North Arm, Fraser River, Vancouver, B.C. (from Levings and Coustalin 1975).

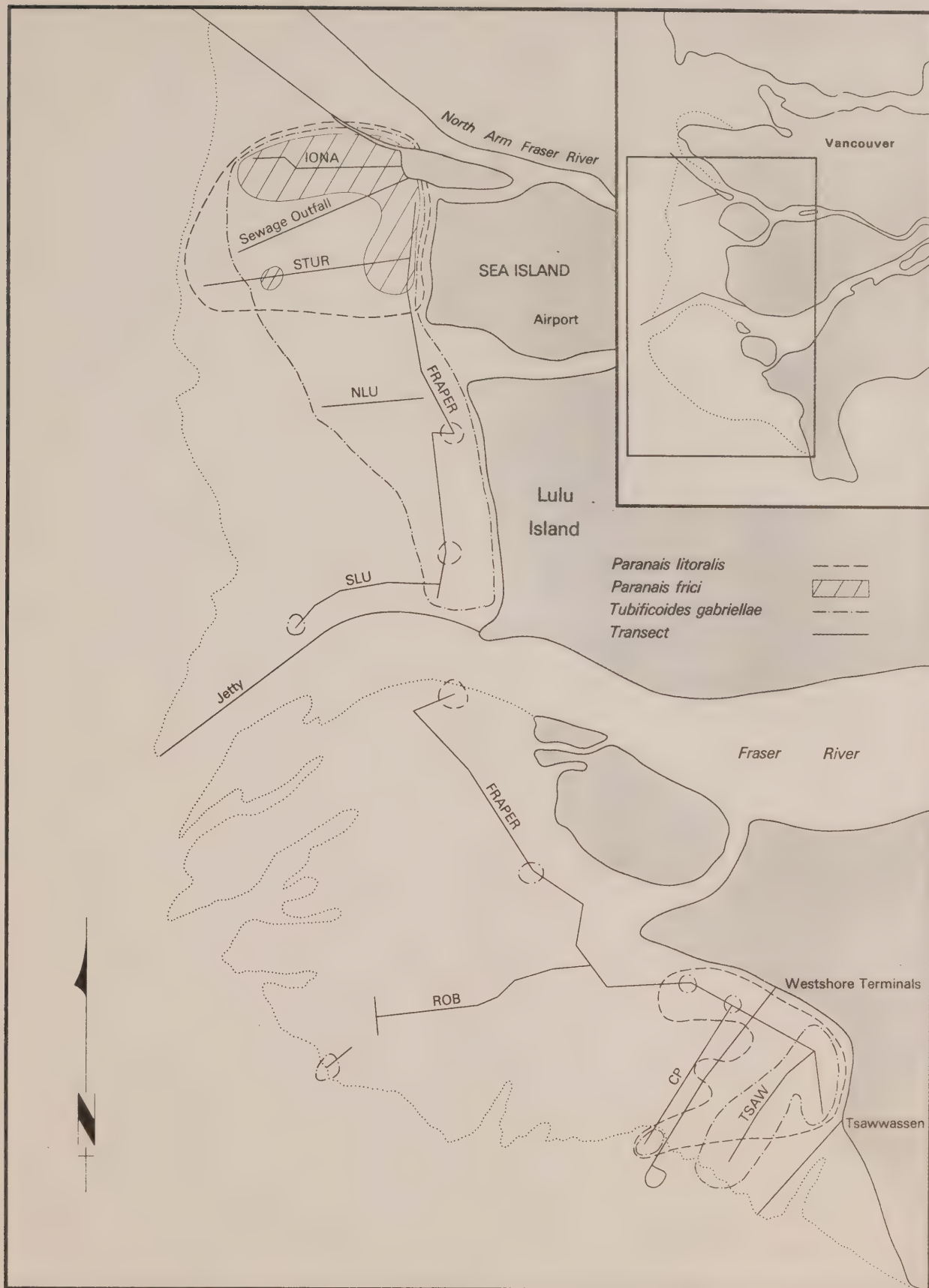


Figure 4 Distribution of species on the delta of the Fraser River, Vancouver, B.C. (from Levings and Coustalin 1975).

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EP321
79R05

**REPORT ON OCEAN DUMPING R AND D
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1977-1978**

**Edited by
S.C. Byers**

Dobrocky SEATECH Limited

and

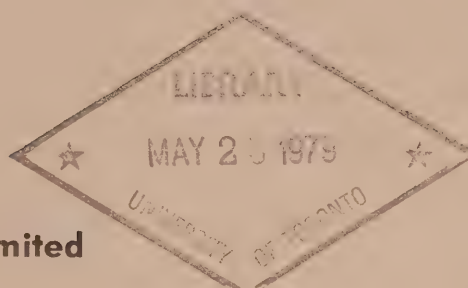
R.O. Brinkhurst

Institute of Ocean Sciences, Patricia Bay

for

Regional Ocean Dumping Advisory Committee (Pacific)

(R.O.D.A.C. (Pacific))



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Institute of Ocean Sciences, Patricia Bay

for

Regional Ocean Dumping Advisory Committee (Pacific)
(R.O.D.A.C. (Pacific))

Institute of Ocean Sciences, Patricia Bay
Sidney, B.C.

1979

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ABSTRACT

This report summarizes the progress and results of the 1977-1978 studies contracted in support of Ocean Dumping legislation and reviews a workshop held for this purpose on September 14, 1978 at the Institute of Ocean Sciences, Patricia Bay, Sidney, B.C.

I. GENERAL INTRODUCTION

This report summarizes the progress and results of the 1977-1978 studies contracted in support of Ocean Dumping legislation and reviews a workshop held for this purpose on September 14, 1978 at the Institute of Ocean Sciences, Patricia Bay, Sidney, B. C.

The contracted studies examine the impact on the marine environment of two dredge spoil components: wood wastes and heavy metals. Alberni Inlet was chosen as the location for field studies for two basic reasons: it receives relatively few other wastes, and it has been studied intensively for its fisheries and for the environmental impact of a pulp mill and saw mills near its head. Alberni Inlet was also the focus of attention for 1976-77 Ocean Dumping studies. The 1976-77 studies were general explorations. The 1977-78 studies concentrated on the mechanisms by which wood wastes and heavy metals, as components of dredge spoil, affect the environment.

Some studies are completed. Others are presented in the form of preliminary results.

This year in the compilation of the workshop report an attempt was made to incorporate the group discussions, which followed the topic presentations, into the text.

The wood wastes and heavy metals topics dealing specifically with Alberni Inlet are discussed in Sections III through V. Section VI covers heavy metals studies in both Alberni Inlet and Howe Sound. Section VII deals with heavy metal investigations in Victoria Harbour and Section VIII summarizes the future needs for other studies. A list of those in attendance at the workshop is given in Appendix I. Contracts for 1977-78 are summarized in Appendix II, and contracted studies for the 1978-79 period are summarized in Appendix III.

Some of the references cited here are manuscripts produced under contract, and are not available for distribution. For further information on Contract Reports IOSPB-CR -, and IOS Notes -, contact the listed Scientific Authority. Pacific Marine Science Reports are also unpublished manuscripts, but are available for limited distribution from the Institute of Ocean Sciences, Patricia Bay.

Wood Waste and Heavy Metal Studies

The studies and their respective contracted consultants are as follows:

III. The collection and analysis of seawater and undisturbed sediment cores in Alberni Inlet, B. C. (Chemex Labs Ltd.).

A. Speaker: P. J. Doyle (Chemex Labs Ltd.)
Metal profiles and sedimentation rates.

B. Speaker: R. W. Macdonald (I.O.S.)
Oxygen profiles and flux.

IV. An oxygen budget study of the deep waters in the inner basin of Alberni Inlet (Dobrocky SEATECH Ltd.).

Speaker: W. R. Buckingham (Dobrocky SEATECH Ltd.)

V. Marine biological sampling and observations of temporal changes in benthic communities and benthic respiration at a dumpsite in Port Alberni (Beak Consultants Ltd., and Dobrocky SEATECH Ltd.).

Speaker: C. D. Levings (P.E.I.)

VI. An analytical support for a study of mercury biotransformation in anoxic estuarine sediments (Willis, Cunliffe, Tait & Co. Ltd.).

Speaker: J. A. J. Thompson (I.O.S.)

VII. The variability in analytical results on dredged spoils and marine sediment in connection with the validity of presently prescribed criteria (Chemex Labs Ltd.).

Speaker: R. W. Macdonald (I.O.S.)

VIII. Possible areas for future Ocean Dumping research.

Speaker: R. A. W. Hoos (E.P.S.)

II. SUMMARY AND CONCLUSION

This report summarizes the progress and results of the 1977-1978 studies contracted in support of Ocean Dumping legislation and reviews a workshop held for this purpose on September 14, 1978 at the Institute of Ocean Sciences, Patricia Bay, Sidney, British Columbia.

Zinc, cadmium and mercury have been added to Alberni Inlet sediments by human activity. Hg levels are just above background but the maximum zinc level is high. Pb levels are low. Oxygen profiles are consistent with the annual cycle, with oxygen levels decreasing progressively up inlet, presumably related to topography rather than dumpsite effects, with contributions from log booming and reduced circulation. The oxygen budget model still requires improvement. The encounter of surface tides with the sill at Sproat Narrows, or the shore at the head of the inlet, or both, produces an internal tide which, with the surface tide, produces large semi-diurnal oscillations of temperature and conductivity.

Having established the distribution pattern of benthos in relation to the dumpsite reported last year, the seasonal variation in this pattern was investigated in the field year under review. Results of this study will be fully available next year, but it is apparent that the dumpsite itself contains fewer species and a lower biomass than control stations. The dumpsite is rapidly recolonized after dumping ceases, mainly by opportunistic species (*Axinopsida serricata*, *Capitella capitata*, *Dorvillea* spp.). The highest number of species at the control site is found in winter to early spring. The large burrows noted in previous photographs appear to be inhabited by a large shrimp (*Axiopsis spinulicauda*) which often plasters its burrow with sediments of high concentrations of heavy metals. While Alberni Inlet is a good location for a case study, the dumpsite seems to have a limited and acceptable impact. In methylation studies with 10 mg kg^{-1} Hg^{2+} added, a maximum production at 15°C occurred after 15 days; thereafter concentrations fell. At 5°C this same rapid initial increase was not observed. There are complications such as differences between autoclaved and formalin treated contents which still require explanation, but methylation rates below 5° are slow and are primarily dependent upon carbon concentrations. Methylmercury degradation is temperature dependent. The apparently high ambient methylmercury in Alberni in contrast to Howe Sound may reflect the elevated organic loadings in the former, which would encourage anaerobic biotransformation processes.

In tests of variability of contaminant levels in dredge materials from Victoria Harbour elevated levels of mercury, cadmium, lead and possibly zinc were detected. The high cadmium levels were detected in the normal routine "permit" analyses. Problems in relation to the wording of the Ocean Dumping Regulations in connection with contaminant levels are obvious, and will be addressed in subsequent chemical studies.

Future studies might be concentrated on:

- a) meaningful criteria for contaminant levels in the Canadian Regulations;

- b) the state of the environment at the Quarantine Buoy dumpsite off Victoria;
- c) further study of the mixing regime in Alberni Inlet, its internal tide and the oxygen budget, and
- d) other local issues such as a dumpsite for Prince Rupert, timing restrictions in the Fraser River and Burrard Inlet, beneficial uses for dredged materials or construction rubble, and the disposal of low-level radioactive wastes.

III. THE COLLECTION AND ANALYSIS OF SEAWATER AND UNDISTURBED SEDIMENT CORES IN ALBERNI INLET, B. C.

Introduction

Three cruises to the area took place in November and December 1977, and February 1978. Two of the cruises were performed under contract to Chemex Labs Ltd. while the third was run by Ocean Chemistry personnel. The objectives of the study were threefold: to obtain box cores from which metal profiles, and then, sedimentation rate would be determined (reported here); to obtain vertical profiles of oxygen concentration; and, to measure oxygen flux into undisturbed sediments by using a Clark-type electrolytic B.O.D. system installed in the ship's laboratory (reported subsequently in Section IV). The box cores were taken during the November cruise: approximate sample site locations are given in Figure 1. Specific details concerning the box cores are found in this section. The salinity, temperature, and oxygen properties were examined during all three cruises and the results of these are covered in the following section concerned with mixing and oxygen budgets. The locations for these stations are shown on Figure 2. As can be seen, the water quality samples were obtained at a line of stations closely spaced and running through the dumpsite. A mini-fix system was used to establish stations on the same frame of reference during successive cruises with the accuracy of the system being ± 5 m.

Box Cores

Sample collection and analysis

Four cores, ranging in length from 24 to 91 cm, were obtained using a Soutar-Bruland box core sampler. Cores were quick-frozen and transported to Chemex Labs for analysis. Since no obvious layering was observed, sub-samples were taken after thawing, at regular intervals along the length of each core. Samples were dried at room temperature, pulverized and mixed. Cu, Pb, Zn, Cd and Fe were measured by conventional atomic absorption procedures after a hot $\text{HNO}_3 - \text{HClO}_4$ digestion. Hg was measured by flameless atomic absorption after a $\text{H}_2\text{SO}_4 - \text{KMnO}_4 - \text{K}_2\text{S}_2\text{O}_7$ extraction.

Results

Results of duplicate analyses of individual samples are summarized graphically in Figures 3-6 (see Twaites et al., 1978). Three more or less distinct element groupings can be defined on the basis of metal profile characteristics: copper and iron; zinc, cadmium and mercury; and, lead.

Copper and iron are distinguished by their essentially uniform distribution throughout the profiles examined. In the case of Fe, concentrations for all four cores typically range between only 3.0 and 4.0 percent. Cu levels in individual cores also vary within relatively narrow limits: $80-90 \mu\text{g g}^{-1}$ for cores 1 and 2, and $45-65 \mu\text{g g}^{-1}$ for cores 3 and 4.

Concentrations of zinc, cadmium and mercury are characteristically somewhat enhanced in near-surface sediment. This trend can be observed in all cores, with the exception of core 2 which penetrated to a depth of only 24 cm. Strongest anomalies occur in core 1, at a depth of 20-25 cm, where Zn, Cd and Hg values reach maxima of 342, 2.1 $\mu\text{g g}^{-1}$ and 265 ng g^{-1} , respectively. Although values decrease progressively as the sediment surface is approached, concentrations in 0-2 cm material remain above local background as inferred from data for deepest sediment samples (30-60 cm depth range). For example, the Hg content of surface sediment of core 1, 105 ng g^{-1} , is considerably higher than the values of 20-40 ng g^{-1} noted in samples from near the base of this core.

Maxima for cores 3 and 4 are somewhat reduced and in the case of core 3, it occurs at a relatively shallow depth (~ 10 cm). Furthermore values for Cd in core 3 and Zn in core 4 do not appear to fall significantly in the uppermost sediment layers.

Lead is unique in that no consistent pattern can be distinguished. Values in core 1 are uniformly low ranging between 2 and 6 $\mu\text{g g}^{-1}$. Concentrations are somewhat higher (up to 16 $\mu\text{g g}^{-1}$) in cores 3 and 4. The trend for core 3 is bimodal in appearance with maxima at the surface and 60-70 cm. In the case of core 3, Pb values increase more or less progressively from about 8 $\mu\text{g g}^{-1}$ near the base to 16 $\mu\text{g g}^{-1}$ at the top.

Discussion

Near-surface enrichment of Zn, Cd and Hg suggests that these elements have been introduced as a result of human activity. Although Hg concentrations in the uppermost sediment of the Inlet (maximum 265 ng g^{-1}) are considerably above local background values (20-100 ng g^{-1}) they are much lower than levels of up to several thousand ng g^{-1} reported in contaminated sediments of Howe Sound (Macdonald and Wong, 1977) and Saguenay Fjord (Loring, 1975). The zinc maximum of 342 $\mu\text{g g}^{-1}$ noted in core 1, however, is considerably higher than the largest value (145 $\mu\text{g g}^{-1}$) noted by Loring (1976) for the Saguenay Fjord.

Although Pb concentrations in surface sediment from cores 3 and 4 are somewhat elevated compared to sub-surface values, absolute concentrations are relatively low and within the range which would be expected naturally in this region. In contrast to low levels noted in this study, Clague (1976) reported Pb concentrations of over 50 $\mu\text{g g}^{-1}$ in polluted marine sediment near Comox.

The absence of surface enrichments of Cu and Fe indicates that these elements are not involved in pollution problems. Higher Cu concentrations in cores 1 and 2 relative to 3 and 4 possibly reflect local changes in sediment source. Zn, Cd and Hg could have been introduced into the Inlet either by mining or pulp and paper milling. Both activities began between 1890 and 1900 (Hines, 1976). Furthermore municipal waste from the town of Port Alberni could also be contributing to concentrations in top-most sediments. If mining was responsible, near-surface enrichment of Cu would be expected since Cu and Au were the main elements of economic interest.

Lack of such enrichment suggests that pulp and paper milling is probably the main source of sub-surface pollution, at least. This suggestion is reinforced by the fact that highest levels of all three pollutants occur in core 1 which is closest to Port Alberni and that Hg pollution has been linked to pulp and paper milling in other areas.

Conclusions

Results of this study suggest that Zn, Cd and Hg have been added to Alberni Inlet sediment as a consequence of human activity. Pulp and paper milling is considered the most likely source, although mining and municipal wastes may have contributed to the problem.

It is recommended that additional cores could be taken near the town of Port Alberni itself where evidence suggests that pollution problems are most severe. Furthermore, in addition to "total" analyses, selective leachates could be employed, as used by Loring (1975), to facilitate differentiation of artificial and natural components of the sediment. Finally the range of elements examined could be expanded to include, for example, such potentially toxic elements as As and Se.

Group Discussion

Attention focused on the problem of sampling variability: much spatial variation occurred in mercury concentrations from the head of the inlet to outside the sill, and lead concentrations varied from core to core. Questions arose as to whether intact core samples were obtained and whether there was confidence in the methods used to determine concentrations (Thompson, Levings, Waldichuk). It was concluded that the variation was due to local sources of sediment (Doyle). Because higher metal concentrations were often associated with finer sediments, an observation from PISCES IV concerning 'flocs' along the trough of the inlet was presented (Hoos), who also asked if consideration had been given to natural sedimentation rates and the possible application of dating techniques. Burial by slumping after earthquakes (e.g., 1964) was also mentioned as a possible cause of variability in element concentrations (English). It was suggested that perhaps the design of the sampling program should be altered, with consideration given to cost, to provide a more realistic picture of the range of variability of metals in the sediments (Brinkhurst). Finally, it was proposed that in comparison to background levels in sediments from other inlets, perhaps the metal levels were not significantly high in Alberni Inlet (Hoos).

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IV. OXYGEN BUDGET STUDIES IN ALBERNI INLET

Part 1. Oxygen Profiles, Flux, and the Conservation Equation.

Oxygen Profiles

During the November cruise there was a sharp gradient in the surface layer with oxygen concentration dropping to 3 mL L^{-1} below the pycnocline. Areal coverage of this cruise was not as large as it was on the two subsequent cruises of December and February: during the latter cruises, oxygen samples were drawn in triplicate or quadruplicate from the bottom bottles to determine the precision of the oxygen analyses under the conditions encountered. From a large number of samples (40) ranging from 0.6 to 1.3 mL L^{-1} it was found that the 95 percent confidence interval was $\pm 0.04 \text{ mL L}^{-1}$, regardless of absolute concentration. Figures 7, 8 and 9 show the vertical oxygen profiles for the three cruises.

Over the sampling period the salinity decreased, with time, at all depths. Below the pycnocline, it dropped from 31.9‰ to about 31.0‰, at 50 m. Average oxygen levels increased from about 0.8 mL L^{-1} to about 2.0 mL L^{-1} . This pattern compares with the annual variations summarized in Bell, 1976. Figures 8 and 9 show the depth contour of oxygen for the upper end of Alberni Inlet where station 1 marks the location of the dumpsite. Both figures, clearly showing the upward trend of oxygen contours north (left) of station 11, denote a general decrease of oxygen as one proceeds up-inlet. This general trend of oxygen depletion toward the head of the inlet is not strictly an advective feature but must be explained in part by oxygen loss from the original water body. This may result from either *in situ* processes such as respiration and decay, or by interaction with the benthic boundary layer where oxygen has been lost to the sediments. Reference to Figure 10, the salinity-oxygen diagram, reveals that the stations south of where the bottom shallows at Stamp Narrows (14, 13 and 7) have oxygen levels lying on a concave upward curve which acts as a ceiling for all of the data points. As one progresses northward, and particularly at stations 6, 12 and 4, the oxygen levels for a given salinity drop by anywhere from 0.5 to 1.5 mL L^{-1} . Narrowing and shallowing of the inlet would increase the bottom area exposed per unit volume of water; thus, a higher surface to volume ratio would be produced. In addition, river inputs and pollution loads from the head of the inlet could increase *in situ* oxygen demand, and restricted circulation would compound the effect. At present not enough is known to assess the relative contributions of these various possibilities, but the decrease in oxygen levels appears to be related more to the topography than to the dumpsite location, and physical processes must surely have bearing on this.

Oxygen Gradients and Flux to Sediments

Problems with the instrumentation and methodology prevented us from obtaining any information on flux to the sediments on the first two cruises, but on the last cruise we were able to make some measurements. The oxygen

gradient measured from oxygen at the ambient bottom levels is given in Table 1. No particular pattern was observed and the average flux was $6.8 \times 10^{-10} \text{ g cm}^{-2} \text{ sec}^{-1}$. From the measured gradient the apparent eddy diffusivity was calculated where possible, and values are shown in Table 1; the average flux calculated was $2.8 \text{ cm}^2 \text{ sec}^{-1}$. This should be compared with the value of $7 \text{ cm}^2 \text{ sec}^{-1}$ determined for 50-60 m in the upper basin based on salt and temperature considerations (de Lange Boom, 1977).

The Conservation Equation

The previous contract has examined the oxygen budget for the deep water of Alberni Inlet, where deep water is taken to mean 50-70 m (de Lange Boom, 1977). It is useful to re-examine this oxygen budget in the light of some of the recently measured variables. The important terms in the conservation equation were seen by de Lange Boom as:

$$\frac{\partial c}{\partial t} + u \frac{\partial c}{\partial x} + w \frac{\partial c}{\partial z} = K_z \frac{\partial^2 c}{\partial z^2} + S \quad -1-$$

where c is oxygen concentration; t is time; u is the velocity down-inlet and w is the velocity upward through the water column; x is distance down-inlet; z is depth positive upwards; K_z is the vertical turbulent diffusivity; and, S is the term covering sources and sinks within the water column. It should be noted that several important assumptions have been made; horizontal eddy diffusion is unimportant, advective transport across inlet does not occur, and K_z is constant.

We will now look at equation -1- term by term suggesting improvements where new data makes this possible. Table 2 summarizes the results of this process.

a) $\frac{\partial c}{\partial t}$

Based on previous measurements made in Alberni Inlet, particularly by Waldichuk et al., 1968, de Lange Boom estimated this term as:

$$- 2.5 \times 10^{-7} \text{ mgO}_2 \text{ L}^{-1} \text{ sec}^{-1} < \frac{\partial c}{\partial t} < - 1.5 \times 10^{-7} \text{ mgO}_2 \text{ L}^{-1} \text{ sec}^{-1} \quad -2-$$

This estimate appears to be quite reasonable in the light of the annual decrease of oxygen in the deeper water of the inner basin during periods when renewal is not occurring. See for instance Figure 2 in Bell, 1976.

b) $u \frac{\partial c}{\partial x}$

u has been estimated by de Lange Boom, 1977, as 20 cm sec^{-1} (down-inlet). Based on estuarine circulation in a fjord one would not expect this fast down inlet flow to be reached in the deeper water (50-100 m). Salt budget requirements indicate that deep water inflow must occur to replace salt mixed up into the fresh surface layer and advected out of the system. Recent current measurements in the upper basin seem to indicate that this is so at 50 m, and that the currents are about 1 cm sec^{-1} (Buckingham,

personal communication). The limit of response of the current meters is $1.5\text{--}2 \text{ cm sec}^{-1}$ so that after filtering out tidal influences the estimate of 1 cm sec^{-1} is still subject to doubt. We will estimate this as

$$u \leq 1 \text{ cm sec}^{-1} \text{ (up inlet)} \quad -3-$$

Oxygen gradient along the inlet at depth was estimated by de Lange Boom from the data of Waldichuk et al., 1978, to be

$$\frac{\partial c}{\partial x} = 1.3 \times 10^{-6} \text{ mg L}^{-1} \text{ cm}^{-1} \quad -4-$$

This estimate could be out by a factor of two due to internal tides in the upper basin, but at present cannot be further refined.

$$c) \quad \frac{w \partial c}{\partial z}$$

Upward velocity, w , was estimated by de Lange Boom to be

$$w \leq 10^{-4} \text{ cm sec}^{-1} \text{ (deep water)} \quad -5-$$

and from the data of Waldichuk et al., 1978

$$\frac{\partial c}{\partial z} = 2 \times 10^{-4} \text{ mgO}_2 \text{ L}^{-1} \text{ cm}^{-1} \quad -6-$$

$$d) \quad K_z \frac{\partial^2 c}{\partial z^2}$$

The value for K_z was determined by de Lange Boom to be about $7 \text{ cm}^2 \text{ sec}^{-1}$ based on salt and heat diffusion downward during periods when renewal of deep water was not taking place. It compares quite favourably with those determined near the bottom during this study. The second part of expression (d) was calculated to be $0.5 \times 10^{-7} \text{ mg L}^{-1}$ by using O_2 depth profiles. Determining the second derivative by this manner is subject to some doubt and the errors involved may be large (Farmer, personal communication). We have carried out a similar process for some of our data below the pycnocline where we have up to nine different depths sampled per station. We found the variability not only to be large but the actual term was found to be negative on some occasions and positive on others. Diffusion of oxygen through a sharp density gradient is very slow (Waldichuk, 1978) and considering that the actual amount of fresh water diffusing into the deep water (50 m) accounts for the slow salinity decline, the estimate by de Lange Boom of $0.5 \times 10^{-7} \text{ mg L}^{-1} \text{ cm}^{-2}$ appears to be too large perhaps by as much as two orders of magnitude. We feel a better estimate is

$$K_z \frac{\partial^2 c}{\partial z^2} \sim 10^{-8} \text{ mg L}^{-1} \text{ sec}^{-1} \quad -7-$$

$$e) \quad S$$

de Lange Boon estimated this factor by calculating the annual production and subsequent decay

$$S \sim 8.3 \times 10^{-8} \text{ mg L}^{-1} \text{ sec}^{-1} \quad -8-$$

Actually the source or sink term is composed of several contributing parts

$$S = S_D + S_P + S_R + S_B \quad -9-$$

where S_D is the removal of oxygen by *in situ* decay within the water. This has not been measured directly but should be attempted. S_P and S_R are the photosynthetic and respiration considerations and are probably small in deep water. S_B is the loss of oxygen to the sediments. The calculation of S by de Lange Boom included both *in situ* demand and benthic respiration; however we now have direct information on benthic respiration. We found the average flux to be $6.8 \times 10^{-7} \text{ mg cm}^{-2} \text{ sec}^{-1}$. Consideration of the topography of the upper basin of Alberni Inlet shows that the area to volume ratio is $0.13\text{-}0.48 \text{ cm}^2 \text{ L}^{-1}$ with the higher ratio obtained in the upper basin reaches. Oxygen removal at the bottom then becomes

$$9 \times 10^{-8} \text{ mg sec}^{-1} \text{ L}^{-1} < S_B < 32 \times 10^{-8} \text{ mg sec}^{-1} \text{ L}^{-1} \quad -10-$$

Increase in bottom roughness in response to dumping or deposition of bark or wood debris, or resuspension of loosely compacted materials such as faecal pellets, would tend to increase S_B .

Having considered all of the terms in equation -1-, it now becomes

$$\begin{aligned} \frac{\partial c}{\partial t} &= (13 - 0.2 + 0.1 - 3.2) \times 10^{-7} \text{ mg L}^{-1} \text{ sec}^{-1} \\ &= 9.7 \times 10^{-7} \text{ mg L}^{-1} \text{ sec}^{-1} \end{aligned} \quad -11-$$

The estimate based on observed decreases with time (equation -2-) is

$$\frac{\partial c}{\partial t} = -2 \times 10^{-7} \text{ mg L}^{-1} \text{ sec}^{-1} \quad -12-$$

Clearly something is not right in equation 11. There are two possibilities; the *in situ* loss of oxygen, S_D , has been ignored and is large ($\sim 13 \times 10^{-7} \text{ mg L}^{-1} \text{ sec}^{-1}$) or the advective term is not right because u has been estimated much too large. The first possibility seems unlikely but the estimation of u was, as noted earlier, not particularly good. If u was an order of magnitude lower, equations 11 and 12 would come exactly into line.

Conclusions

Oxygen levels in the upper end of the upper basin along with near bottom gradients and measured benthic oxygen fluxes do not indicate that the dumpsite is an important point sink. The shallow region north of Stamp Narrows has generally lower oxygen levels which may be a result of increased surface to volume ratios, log booming operations and reduced circulation.

Re-examination of the conservation equation as set forth by de Lange Boom, 1977, showed that the estimation of several terms could be improved but that balance is still not satisfactorily achieved. Further information

on deep currents is required, and direct measurements of the *in situ* oxygen demand of seawater need to be made in Alberni Inlet. Furthermore the removal of oxygen which takes place during dumping needs also to be measured in the field.

Group Discussion

This talk provoked much discussion about the validity of values used in Bodo de Lange Boom's preliminary oxygen budget model (1977). For example, an attendee noted that eddy diffusion is very dependent on the halocline configuration, especially when seasonal changes cause alterations of the freshwater lid. This has a direct influence on the amount of oxygen mixing into the water column (Farmer). It was noted that data from layers immediately adjacent to the bottom are also very important (and scarce) with respect to the significance of plankton and detritus in the amount of oxygen taken up by the sediments (Waldichuk). It was mentioned that the dumping of organic debris can cause immediate depression of dissolved oxygen in local areas but, in fact, this phenomenon has not been observed on all occasions (Anderson, Macdonald).

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Part 2. An Oxygen Budget Study of the Deep Waters in the Inner Basin of Alberni Inlet

Introduction

Dobrocky SEATECH Ltd. undertook a physical oceanographic program in November of 1977 in the upper reaches of Alberni Inlet. The primary purpose of this study was to improve the understanding of the oxygen budget in the deep waters of the inner basin of this inlet where the active dumping of dredge spoils imposes an oxygen demand. Measurements of dissolved oxygen, temperature, salinity, and current speed and direction were taken in order to provide insight into the natural variability of the deep water properties of the inner basin on time scales not previously examined.

Six hydrographic stations were designated in the inner basin as denoted on Figure 1. Three Aanderaa RCM4 current meters were moored on one mooring near Station 3 at depths of 50 m, 75 m and 100 m. These current meters recorded temperature, conductivity, pressure, direction, and speed at intervals of five minutes. Three series of hydrocasts were done using Niskin bottles and reversing thermometers.

The first series, lasting 4 days, consisted of hydrocasts at Station 1 through 4 during one low slack water and one high slack water each day. The second series was a 25-hour anchor station at Station 3 with one hydrocast every hour. The third series consisted of hydrocasts at Stations 3W, 3, and 3E during high slack and low slack water during one day. These series provided an indication of the longitudinal, temporal and transverse variations of temperature, salinity, and dissolved oxygen. One week prior to the commencement of the hydrocast series current meters were installed to determine if the inlet system had undergone any major changes preceeding the period of interest.

Results

In assessing the heat, salt and oxygen budgets of the deep water in the inner basin, the most conspicuous local phenomenon which became evident throughout the current meter time series records were the large semi-diurnal oscillations of temperature and conductivity. Figure 11 provides clear evidence that these oscillations are not merely manifestations of the surface tide effect; rather, not only are the amplitudes of the oscillations much larger between 50 m and 90 m depth than at the surface, but also the internal oscillations are about 90° out of phase with the surface oscillations. These internal disturbances probably occur as a result of an encounter of the surface tide with the sill at Sproat Narrows, or with the sloping shore at the head of the inlet, or with both.

It is the surface and internal tides in the inlet which are the main causes of oscillatory currents. Below 50 m these oscillatory currents did not appear to be dominated by the surface tide as they were approximately 180° out of phase with it. The velocity, temperature, and salinity records

from the current meters indicated that the horizontal currents were also out of phase with the internal tide, by approximately 90° . It appears, therefore, that the internal wave, as observed, was a standing wave caused by the superposition of two progressive waves, one travelling from the head to the sill and the other from the sill to the head. The current meter records suggest relatively smooth sinusoidal characteristics for this standing wave. For such a wave to be produced, the length of the basin from head to sill would have to be nearly the same length as an integral number of half wave-lengths of the internal wave. Since there were no measurements of the wave length of the observed internal tide during this study, the standing wave hypothesis was approached analytically using the measured density gradient for calculations. Assuming that the inner basin could be approximated by a rectangular basin of constant depth, and the density profile by an exponential, the wave length of the first mode was calculated to be 34 km. Thus the length of the basin (17 km at surface, 13 km at sill depth of 37 m) is indeed comparable to half the wave length of the internal wave of the first vertical mode.

The amount of data obtained during this study proved insufficient in providing a complete picture of the short term (semi-diurnal) variations of these parameters. Estimations of what a more detailed time series would have looked liked (based on current meter records of temperature and conductivity and also temperature, salinity, and dissolved oxygen profiles from hydrocasts) were assimilated to give a more complete picture of these parameters. Figure 12 depicts isopleths estimations and Figure 13 depicts isotherms. With the knowledge of the probable structure of the internal tide it was possible to calculate reasonable error bounds in the determination of the budget terms.

Discussion

In considering the conservation equations for heat, salt, and dissolved oxygen, several simplifying assumptions were made. From the data, cross-inlet gradients of temperature, salinity, and dissolved oxygen appeared negligible, although initially the temporal manifestation of internal tidal oscillations made the inlet appear to have transverse gradients. The horizontal turbulent transfer mechanism was assumed sufficiently small compared to the advective and vertical turbulent transfer mechanism because of the narrowness and length of the inlet. The source term for salt was taken as zero while the source term for the heat was assumed negligible since the heat budget was calculated for depths greater than 50 m. Thus, for the heat, salt and dissolved oxygen budgets, the dominating terms were considered to be the time, rate of change, horizontal advection, vertical advection and vertical turbulent diffusion. The oxygen budget was also influenced by a "sink" which was mainly the result of plankton decay and dredge spoil leachates.

The time rates of change of dissolved oxygen calculated at 50 m and 60 m ($-0.13 \pm 0.04 \text{ mg L}^{-1} \text{ day}^{-1}$ and $-0.07 \pm 0.04 \text{ mg L}^{-1} \text{ day}^{-1}$ respectively) have the same sign and are within an order of magnitude of that calculated ($0.012 \text{ mg L}^{-1} \text{ day}^{-1}$) from Bell's (1976) data for the 100 m depth from June

to December 1966. de Lange Boom (1977) reports values of this term ranging from $-0.012 \text{ mg L}^{-1} \text{ day}^{-1}$ to $-0.022 \text{ mg L}^{-1} \text{ day}^{-1}$ as calculated from data by Waldichuk and others. However, it must be remembered that Bell's and de Lange Boom's calculations were based on data gathered over many months and that the observed variability in the rate of change of concentration of dissolved oxygen over short time periods was quite substantial, even to the extent of changing from a decrease in oxygen to an increase in some instances.

The calculations for the longitudinal variations of temperature, salinity, and dissolved oxygen were hampered by large uncertainties due to the existence of a large internal tide and the unknown phase relation between the internal tide and the hydrocast measurements. Also, the amplitude of the wave was unknown at stations other than station 3. The error estimates for the longitudinal gradient terms were of the same order of magnitude as the terms themselves, and since the mean velocities associated with these scalar quantities were measured to be very small, and their error bounds quite large, the determination of the horizontal advection terms was somewhat tenuous. From the current meter records, the longitudinal components of the net current were calculated to be as follows:

| DEPTH (m) | NET VELOCITY (cm sec^{-1}) |
|-----------|---------------------------------------|
| 50 | -0.79 ± 1.5 (up-inlet) |
| 75 | -0.73 ± 1.5 (up-inlet) |
| 100 | 0.48 ± 1.5 (down-inlet) |

With both the time rates of change and the advective rate of change terms being as small as they were and having such large error bounds, it was difficult to surmise anything conclusive from the budget. These two terms balanced each other within their error bounds, but it is felt that vertical turbulent diffusion must also play a major role in the deep waters of the inner basin.

Conclusions

The heat, salt, and dissolved oxygen budget calculations for this study were hampered by the smallness of the measured terms and the largeness of the error bounds. This situation was due to the very short time span of the study, the slow changes occurring in the deep water, and the large oscillatory variations of the measured parameters. It was demonstrated that the mean exchange processes of the deep waters of the inner basin were very slow and almost immeasurable over a short time period. There was an indication, however, of a large semi-diurnal internal tide generated by the surface tide on the sloping head of the inlet which manifested itself as a standing wave by being reflected off the inner sill at depths below 37 m. Although the amplitude of this internal tide appeared quite large (maximum of about 10 m at 65 m depth) it is not expected that it would have a large amount of energy associated with it, as the vertical density gradient at this depth was quite small.

Group Discussion

Following this talk there was considerable discussion of problems related to aliasing of oxygen measurements due to internal tides and the fact that short-period dynamic effects dominate the system.

It was concluded that in spite of the fact that financial constraints often precluded detailed work (e.g., 25 hour data at single stations) it was still necessary in order to obtain an adequate knowledge of the internal tide and its influences. If the structure of the internal tide were better understood, then the uncertainty associated with spot measurements, as opposed to time series, could be estimated (Farmer, Waldichuk). Specific mention was given to the now-evident uncertainty problems related to historical data in this area.

Finally, the dissolved oxygen depression at the heads of inlets with fresh water runoff is often attributed to estuarine circulation; however, it was pointed out that some lowering in dissolved oxygen often exists towards the inshore ends of inlets or fjords that are not estuaries, an example being, Prince Rupert (Anderson).

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V. BIOLOGICAL COMMUNITIES

Introduction

Biological work on the effects of dumping on the benthos in Alberni Inlet has included determinations of immediate effects and studies of the rate of recovery following cessation of disturbance. The preliminary effort involved a study of the effects of dumping dredge spoils containing wood debris on benthic communities and was performed under contract by Dobrocky SEATECH Limited in 1976 (Anderson and O'Connell, 1977). A summary of the data and clustering analysis of community structure is available in the previous ocean dumping report (Brinkhurst, 1978). In an attempt to understand more of the temporal changes and benthic respiration at the dumpsite, a one year monitoring program was implemented. Initial stages of the program were performed under contract to Beak Consultants Limited in November 1977 and carried through until March 1978 (Beak Report, 1978). During the interim between contracts, MacMillan Bloedel Limited provided financial support for the program. Table 3 gives a summary of the sampling effort to date. Completion of this sampling program is presently undertaken by Dobrocky SEATECH, with the last sampling period expected to occur in November. Consequently, only preliminary results of the observed temporal changes on the benthic communities are available.

Two sampling stations were visited at intervals throughout the twelve month period. The dumpsite station was located on the west shore of the upper basin of the inlet about one mile south of Stamp Point at approximately 56 m depth; and the "control" station was in about 66 m depth, on the eastern side of the inlet abreast the dumpsite. Triplicate benthic grabs were taken at each of the two stations using a 0.1 m² Smith-McIntyre grab.

Sediment samples from each of the six replicates were analyzed for total Kjeldahl nitrogen (percent N), total organic carbon (percent TOC), volatile fraction, moisture and silt-sand ratios.

Oxygen consumption of the benthos was measured with a tethered *in situ* respirometer. This device consisted of an instrumented chamber which was lowered to the ocean floor to provide a continuous on board readout of salinity, temperature, pH, and dissolved oxygen.

Results

Preliminary results demonstrate that the dumping of dredge spoils containing wood debris has an immediate effect on the benthic fauna. Consistently fewer species were present at the dumpsite station as compared to the "control" or less-disturbed station, and as one might expect, the biomass was also consistently lower at the dumpsite. After the cessation of dumping there was a rapid colonization of the dumpsite by opportunistic species such as the bivalve *Axinopsida serricata* and the small polychaetes *Capitella capitata* and *Dorvillea* spp. *Dorvillea* and *Capitella* are commonly found in disturbed environments. Recolonization by opportunistic species

was rapid. Juvenile *Axinopsida serricata* settled at the dumpsite within three to six weeks. A peak in the numbers of species occurring at the control site can be identified during the winter to early spring. This can be accounted for in several ways including low bottom current flow, colder temperatures, higher oxygen content in water column and the ultimate settling out of larval forms at this time of the year.

Axiopsis spinulicauda, the Alberni "super-shrimp" was found in several samples. It may be the animal responsible for large and numerous burrows observed previously in photographs of the inner basin. This shrimp was found only at the control site in this collection. The burrows of *A. spinulicauda* are often plastered with sediments which contain high concentrations of heavy metals. This may prove to be an important topic for further study.

Analyses of the sediments revealed that the nitrogen content was consistently higher at the control station than at the dumpsite (ca. 0.3 percent vs. 0.1 percent). Weight loss on ignition was also higher at the control site (16 percent vs. 3 percent). Dumpsite sediments contained a high proportion of sand (60 percent vs. 15 percent), which probably represents dumped material with a large content of riverine bedload. The pattern of differences between dumpsite and control sediments may be explained in part by the addition of dredged material to the dumpsite and in part by the notable concentration of faecal pellets at the control station.

The dissolved oxygen measurements at the dumpsite were not significantly different from the control site measurements. Table 4 provides a summary of the *in situ* measurements of benthic oxygen demand. It is some indication that as the ambient O₂ levels increase, the benthic O₂ consumption also increases.

Conclusion

Only preliminary results are presented at this time. Once the field work and analysis have been completed, more definite conclusions with regard to seasonal variation of the benthos, benthic oxygen demand, and the rate of community recovery from disturbance can be drawn.

Group Discussion

The question was raised as to the possibility of a relation between the internal tide and O₂ level fluctuations (Brinkhurst). The resulting discussion reflected the conclusions drawn from the previous presentation on O₂ budgets: if adequate knowledge existed of the internal tide in the inner basin, a better description could be given of the effect of the tide on O₂ level and benthic oxygen demand. It was concluded that a monitoring program such as is in progress was sufficient to give an understanding of the effects of dumping and natural seasonal changes on the benthic community in Alberni Inlet. It was also stated that with respect to the heavy metals, enough information has been collected to indicate that concentrations are not so high as to cause immediate alarm (Brinkhurst).

This led to a more generalized discussion on Alberni topics chaired by Dr. Brinkhurst. It included such questions as how much ocean dumping has to do with O₂ budgets, and whether or not there was a necessity for money to be spent on general research problems as opposed to site-specific ocean dumping studies. Discussion centered on the proposition that the O₂ budget studies were approaching the "outer boundary" of work that should be totally funded by the Ocean Dumping research money. Unsolicited proposals were suggested as a possible supplemental route for some of this work. Attention was drawn to the point that although dumping effects in Alberni Inlet are acceptably small, as demonstrated by the Ocean Dumping exercise, the inlet still provides an ideal case study (Farmer).

Concern was expressed that toxic materials such as polychlorinated biphenyls and heavy metals in wood wastes were being laid down in thick layers, such that only the surface of a deposit was exposed to natural degradation processes. Consequently, it was offered that a limitation on the total volume to be dumped (depending on the nature of the dredge spoils) should be considered (Waldichuk). Wood wastes and other oxygen-demanding substances are still a serious problem for RODAC applications so a continuation of the oxygen budget work, by whatever means feasible, was advocated.

Before adjournment, the chairman mentioned pertinent areas for the afternoon's discussion: timing restrictions during reproductive cycles of fishes; the need of more credible limits on materials; and, the suggestion of capitalizing on the oxygen budget information in the sense that portions of it could be applied elsewhere.

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VI. BIOTRANSFORMATION OF MERCURY IN SEDIMENTS

Introduction

In previous work (Wong, Thompson and Macdonald, 1977) a series of experiments and field studies was undertaken with two objectives in mind: to determine background concentrations of methylmercury in Howe Sound, B. C.; and, to ascertain some of the characteristics of an estuarine sediment sample with respect to the ability to methylate inorganic mercury. Surveys indicated that the CH_3Hg concentrations throughout the inlet never made up more than about 1 percent of the total mercury burden. Biotransformation experiments indicated that microbial action with the addition of mercury, as Hg^{2+} , did not result in large increases in organomercurial concentrations. It was found also that the efficiency of methylation was greater when 10 mg kg^{-1} of Hg^{2+} was added than it was at the addition of 100 mg kg^{-1} ; however, absolute amounts produced were greater in the latter case. For either dose concentration the maximum CH_3Hg production at 15° occurred at about 15 days after commencement of the experiment.

The opportunity to work with sediments for Alberni Inlet prompted us to consider various aspects: a comparison of CH_3Hg concentration in Alberni Inlet sediments with those in Howe Sound; a comparison of methylation rates in Alberni sediments when dosed with $10 \text{ mg kg}^{-1} \text{ Hg}^{2+}$ at 5° and 15° with those of blank sediments incubated at the same temperatures; and finally, the determination of the capability for demethylation of added methylmercury.

In the first of a set of experiments, begun in November of 1977, a series of incubations was performed over a period of 40 days. Using the sediment from a grab obtained at $49^\circ 11.65' \text{N}$, $124^\circ 49.3' \text{W}$, flasks containing 90 g of sample were incubated at 15° anaerobically. Eighteen samples were spiked to 10 mg kg^{-1} with Hg^{2+} using $^{203}\text{Hg}^{2+}$ as a tracer. The production of CH_3Hg was monitored by duplicate sampling at days 2, 5, 12, 15, 20, 25, 30, 35, and 40. Another eighteen samples were spiked to $2.5 \text{ mg kg}^{-1} \text{ CH}_3\text{Hg}^*$ as Hg incubated anaerobically and sampled in duplicate on the same sequence of days. Blank samples (no mercurial added) were incubated to determine methylmercury production utilizing ambient mercury, and additionally, a set of sterile controls was incubated to determine the background levels of mercury. Sterilization was by both autoclave (high pressure steam) and by formalin additions.

In February 1978 a second set of experiments, using fresh sediment, was initiated. The incubation period for this set was reduced to 20 days and the autoclaved controls were not prepared.

Organic carbon, total mercury and particle size determinations were made for each of the two bulk samples.

*

This unrealistically high value of CH_3Hg was a result of a miscalculation of the concentration.

Results

Methylmercury Production

At the 15° incubation temperature, methylation was readily measurable, reaching a maximum of about 16 mg kg⁻¹ after 15 days (Figure 14). Concentrations decreased steadily from this point, reaching the same levels determined at day 2. Sterile controls exhibited no net changes in CH₃Hg concentrations over the 40 day period, although the mean for the autoclaved samples was nearly twice that of the formalin treated set.

Data obtained for CH₃Hg production at 5° (Figure 15) do not indicate the same initial increase noted at 15°. There is, in fact, a rapid decrease between days 2 and 5 followed by a gradual increase up to the termination of the experiment. Concentrations in the formalin controls were considerably greater here than for the 15° study. Again, these samples did not exhibit a net change in CH₃Hg concentration.

Production of CH₃Hg in the unspiked blanks (Figure 16) showed a marked difference between the two temperature treatments. At 15°, production reached a maximum of about 4 mg kg⁻¹ at 10-15 days while after 20 days, production at 5° appeared to be approaching a plateau of about 6-7 mg kg⁻¹.

Methylmercury Degradation

Methylmercury added at the 2.5 mg kg⁻¹ level was rapidly degraded at 15° (Figure 17). By day 5, approximately 20 percent of the original amount remained. At day 40, about 10 percent remained suggesting both a fast and a slow mechanism are operative.

The rate of degradation at 5° was less, with 43 percent of the original amount remaining at the end of the shorter experiment. At 15° the decay curve can be expressed by the equation $y = 2.36x^{-0.318}$ ($r = -0.97$; $p < 0.001$). According to this equation the half-life for the reaction is approximately 7 days.

At the lower temperature the decay curve can be expressed by the equation $y = 2.90x^{-0.127}$ ($r = -0.84$; $p < 0.01$) and the half-life in this case is about 27 days, or about 4 times greater than at 15°.

Background Mercurial Concentrations

The only data of methylmercury values available from Alberni Inlet are those of the duplicate samples taken from each of the two grabs obtained in November 1977 and February 1978. Data for CH₃Hg total mercury, moisture and carbon content are summarised in Table 5.

It is to be noted here that methylmercury concentrations in the two samples differ by a factor of about 2, and percent of the total as organomercury is about 3-fold more for the latter samples. Carbon and water content show almost no differences.

Discussions

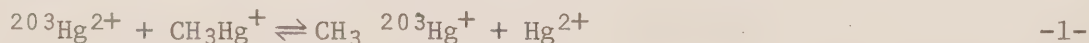
Methylmercury Production and Ambient Concentrations

At 15° and with the 10 mg kg⁻¹ Hg²⁺ spike, production of methylmercury in this work followed a path similar to that found in the Howe Sound studies. Peak production occurred at 10-15 days; thereafter, time quantities decreased. It is somewhat difficult and probably quite academic to compare absolute amounts of mercurial produced because the quantities were expressed in a differing manner.

The lowering of the incubation temperature to 5° had a marked effect upon CH₃Hg production. In the 20 day experimental period there was no net increase although a trend to increasing concentrations (Figure 15) was apparent by day 20. The drop between days 2 and 5 cannot be explained although there is a possibility that the data point for day 2 may be erroneous. An alternative, but less likely possibility is that there was a rapid production of the mercurial during the first 2 days. This occurrence would be missed with the sampling scheme that was used.

The difference in methylmercury levels between the autoclaved and formalin-treated controls (Figure 14) is also difficult to explain. Since extraction efficiencies for the two media were similar, effects of the formalin can be ruled out. There may be, however, intrinsic differences in the chemistry created by the sterilization procedures.

In the 5° experiment a considerably higher background was found for the formalin-treated controls compared with the 15° experiment. Here there is a possibility that this may be a reflection of the higher ambient CH₃Hg concentrations. Through a ligand exchange mechanism, some of the ²⁰³Hg²⁺ would be incorporated into the existing CH₃Hg according to the following reaction:



This would, in turn be extracted and detected by the measurement system.

It can be concluded that at ambient sediment temperatures of 5° or less the methylation process is slow and primarily dependent upon carbon concentrations.

Degradation of Methylmercury

The effect of temperature upon the rate of degradation is clearly marked in this study. At the lower temperature the rate, as defined here by the calculated half-life of the added CH₃Hg, was one-quarter that at 15°.

These experiments also demonstrated that microbial populations, especially in organically rich sediments are capable of mediating even high, unrealistic additions of methylmercury. These results serve further to demonstrate that natural mediation controls the budget of methylmercury in sediments. This would give some support to Windom's (1976) conclusion that

methylation appeared to be an inefficient mechanism for transferring mercury out of (salt marsh) sediments.

Ambient Organomercurial Concentrations

The lack of an inlet-wide survey prevents us from concluding that the sediments of this inlet contain particularly high CH_3Hg concentrations relative to the total mercury. We have seen previously that CH_3Hg in Howe Sound did not amount to more than about one percent of the total. In this study we have found methylmercury up to 12 percent of the total mercury (approximately 600 mg kg^{-1}), particular to this area where the sediments have been perturbed by the dumping of wood-waste-rich materials. Data from core samples described elsewhere in this report (see Section III) give a maximum mercury level of 260 mg kg^{-1} . Studies by other investigators, in the past, have demonstrated the strong relationship between carbon and mercury. Thus, within the area of influence of the dumpsite in Alberni Inlet, total and organomercurial levels could be understandably high.

Conclusion

We may conclude that sediments of Alberni Inlet are comparable in ability to those from Howe Sound to support synthesis of methylmercury. That the proportion of ambient methylmercury apparent in Alberni is greater may reflect elevated organic loadings which will encourage anaerobic biotransformation processes.

Further questions regarding rates of methylation and demethylation are now more suited to long-term research. Probably of immediate concern to Ocean Dumping interests would be the consideration of the distribution of methylmercury in Alberni Inlet, and the possibility of the benthos containing higher than "normal" levels of methylmercury.

Group Discussion

As a possible alternative to the naturally occurring mercury in sediments, slimicides from pulping operations in years past were suggested as sources for the mercury identified (Waldichuk, Harbo).

References

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VII. VARIABILITY STUDY ON DREDGED SPOILS

Introduction

A major problem in monitoring for ocean dumping is the question of how to sample effectively for chemical contaminants. Clearly, large volumes of sediment are dredged and dumped every year: over $3 \times 10^6 \text{ m}^3$ have been dumped in the Pacific Region in 1977, 736,000 m^3 of that going to the Point Grey dumpsite alone. There is a real difficulty in distinguishing those dumps which are "no problem" from those which could lead to environmental deterioration. This task is complicated in that limited resources are available to do this work. It is obviously unreasonable to ask for total analysis on all dumped material simply because expense would be prohibitive; however, sampling should be conducted frequently enough, and in such a way, that undesirable dumping is not carried out.

An examination of the variability of a number of commonly requested parameters was made on one particular dredge event carried out in Victoria Inner Harbour in late 1977, early 1978. The sampling strategy involved obtaining seven grab samples at random locations throughout the dredge site before dredging commenced. In addition, four of the barges were sampled at seven random locations within each barge after it had been filled with spoil. Each sample was then split into three subsamples, stored in containers appropriate to the analysis to be performed and then randomly numbered. The total 105 samples were provided to Chemex for analysis; they were completely unaware of the order of samples. Parameters determined for each sample included trace elements (Pb, Cd, Cu, Zn, Fe, As, Hg), organic carbon, oxygen uptake, percent moisture, petroleum hydrocarbons and total extractable organic material. In addition particle size distribution was obtained for each of the original samples, but not in triplicate. After, the analytical results were submitted to Ocean Chemistry (Chemex Report, 1978) they were decoded and subjected to analysis of variance wherein the significance of difference between means of sample populations could be tested (Zar, 1974).

Results and Discussion

Table 6 summarizes the results of the analyses performed and Table 7 shows the results of the ANOVA tests. The level of most of the parameters may be described as not unusual but mercury, cadmium, lead and possibly zinc are all high. Of particular note, the mercury was found to average 1.9 mg kg^{-1} and the cadmium 1.28 mg kg^{-1} . These reported levels should be seen in the light of the maximum concentrations prescribed by the Ocean Dumping Control Act:

" . . . for mercury and mercury compounds in a solid phase of waste, 0.75 milligrams per kilogram, . . . "

" . . . for cadmium and cadmium compounds in a solid phase of waste, 0.6 milligrams per kilogram, . . . "

Why these metals are unexpectedly high in Victoria Harbour is an interesting question in itself, and at present they appear to originate from a paint manufacturing installation. Further work is in progress by E.P.S. (Environmental Protection Service) to determine the extent of heavy metal contamination throughout the area.

In Table 8 the reported analyses required for R.O.D.A.C. for the permit pertaining to this dump (443-0375) are given. Their R.O.D.A.C. analyses were obtained independently in the course of the normal permit process. In this way we would be able to use Ocean Chemistry's data to check the screening process directly, at least for this dump. Examination of Table 8 shows that the "permit" analyses identified the high cadmium levels and, in fact, both of the samples have concentrations just slightly above the limits found in our study (Table 6). Their levels are clearly in excess of the Regulation 0.6 mg kg^{-1} whether that be regarded as wet or dry weight. Based on the normal distribution obtained from our data there are only six chances in 1000 of obtaining a single sample that high and four chances in 100,000 of obtaining two independent samples both that high. Analytical technique, however, including extraction procedures, may be an important aspect contributing to the difference between those analyses submitted for the permit and our calculated mean. This points out the importance of normalizing techniques for analysis of dredge spoil so that intercomparative evaluations can be made. The Dumping Act does not at present address this problem.

The mercury levels obtained in the course of the R.O.D.A.C. permit procedure were $0.65 - 0.81 \text{ mg kg}^{-1}$ (\bar{x} .73) wet weight. If we assume the value of 0.75 mg kg^{-1} in the Canadian Regulations to apply to wet weight of dredgeate, then these would indicate a marginally acceptable condition. However, the Ocean Chemistry study values averaged 1.90 mg kg^{-1} dry weight. As average moisture content was c. 50 percent, the samples would be about 0.95 mg kg^{-1} wet weight, or more clearly in excess of the Regulation limit. If, of course, the Regulation limit be 0.75 dry weight, then the levels obtained in both sets of analyses are well in excess of the legal limits (i.e., 1.5 or 1.9 respectively). If we assume the Regulation to be set on a wet weight basis, any single sample would be found to be below 0.75 dry weight 1 in 10 times (assuming normal distribution or 2 samples both below 1 in 100).

The situation for cadmium is almost identical. Obviously two samples taken randomly give us a very good chance of identifying the high levels, and in agreement with this the analyses performed for the permit have done so quite successfully. (A high point source would probably be missed but it is difficult if not impossible to catch something like that without blanket sampling.) Again, the mean moisture level of the samples taken from the Victoria Inner Harbour site was found to be c. 50 percent, ranging from 27.3 to 65.9 mg kg^{-1} ; hence, the confusion regarding wet or dry weight, not specified in the Regulations, could affect interpretation by a factor of four. (The wet weight basis analyses would always be the lower.)

Tightening up the wording of the Act is required in order to avoid such future interpretive problems and, of course, the permit requirements for analysis must specify how results are to be reported. Furthermore, literature

values for mercury in natural marine sediments vary over a range of levels including 0.05 to 3.0 mg kg⁻¹ and for cadmium 2.0 to 5.0 mg kg⁻¹. In view of this, fixed prescribed levels do not appear to be reasonable, and site-specific allowance should be made based on natural background levels.

Table 7 shows the preliminary results of the analysis of variance. The first column gives an indication of the amount of spread in the data which was caused purely by splitting a single sample and analyzing it. In the case of lead and arsenic the 'variance accounted for' amounts to more than 50 percent of the total variance, and probably reflects on the analytical difficulties. Similarly the F₁, F₂ and F₃ fractions are also subject to high variation, probably because of imprecision in the analysis. In general the smallest 'variation accounted for' is between individual barges and the pre-dredging sampling program. As a result, samples taken at any time before or during dredging appear to be fairly representative of the whole. Differences between the grab-sample survey and between barges were generally significant at the 99.99 percent level, P < .001, but the differences were not large. (See Table 9.) The large number of samples resulted in statistical power sufficient to detect the small differences. For that reason the 'variance accounted for' is probably a more useful indication of how much of the sample differences could be ascribed to the different causes: within a single grab, between grabs on the same barge and between barges.

The analyses for extractable organic material shed light on another aspect of the maximum quantities of pollutants prescribed by the Dumping Act. In Table 6 it can be seen that the average organic material remaining (after removing non-hydrocarbons) is 1470 mg kg⁻¹ (SAP EOM). Even the 2-3 ring aromatics (F₂) and polynuclear aromatics (F₃) have concentrations of 249.9 mg kg⁻¹ and 118.3 mg kg⁻¹ respectively. The Act dictates:

For crude oil, fuel oil, heavy diesel oil and lubricating oils hydraulic fluids and any mixtures containing any of them, any quantity that yields more than 10 milligrams per kilogram of n-hexane soluble substances . . .

Obviously the levels reported here are way above those prescribed in the Act, and furthermore if this regulation were strictly enforced probably only deep sea sediment would qualify for dumping. In addition to prescribing an arbitrarily low level for extractable material, an n-hexane extraction is specified. This technique is now rarely used to extract oily substances, and updating of the Act should be undertaken based on recent advances in analyses and extractable organic levels normally found in non-polluted coastal marine sediments.

Preliminary step-up multiple regression analysis shows that, as predictors of observed iron concentrations, the elements fall in the order cadmium, zinc, arsenic, copper, lead and mercury. Both cadmium and lead appear to be related to iron content of the sediment while mercury is only marginally so. From the literature and some of our own data we have found that mercury is often associated with the organic carbon content. This may

have a great deal to do with how metals are scavenged to the sediments and also what conditions will effect their release during dredging or dumping. Further analysis, including other parameters, is still in progress.

During the sampling period each grab was characterized according to its physical appearance with colour, odour and texture being noted. Analysis of variance will be performed on data grouped according to physical appearance to see if differences in pollutant level exist. If this is the case it might be used by the "clever" sampler to bias analyses in his favour. It could similarly be used to obtain a worst-case sample which would increase confidence that material judged suitable for dumping, was indeed suitable.

Conclusions

The analyses reported for the dredging in Victoria Harbour make it apparent that nothing should be taken for granted when dredging-dumping is carried out in an area where there are no previous analyses available. It is essential, therefore, that greater care be taken with the first such dumping. Thereafter, the requirements can be diminished if no "surprises" are detected.

Now that statistically valid information on metal concentration and variability has been obtained from Canadian waters, it is an opportune time to clarify or alter threshold levels specified by the Ocean Dumping Control Act.

Group Discussion

Considerable discussion followed concerning known polluted harbours, for example, False Creek, Squamish and Victoria and the effort that should be expended in sampling before permission is given to dump dredge spoils from there.

References

- Twaites, B. L., Doyle, P. J. and Armanini, G. 1978. Alberni Inlet ocean dumping study. Vancouver, Chemex Labs Ltd. Contract Report IOSPB-CR-25: 43 pp.
- Zar, J. H. 1974. Biostatistical Analysis, Prentice Hall, Inc. 620 pp.

VIII. POSSIBLE AREAS FOR FUTURE OCEAN DUMPING RESEARCH

A brief summary on the future of ocean dumping was presented as the closing session for the workshop. Several points were identified with emphasis placed on the Ocean Dumping Act and its regulations.

1. Mercury, cadmium and PCB's are generally the parameters of concern in dredged material and on occasion they can exceed regulated levels. The prescribed concentrations are somewhat arbitrary and/or vague, and do not necessarily reflect possible or real environmental effects or concerns. The regulations should be modified to reflect scientifically sound requirements. This approach can be furthered through additional research into the chemistry and biochemistry of the contaminants of concern: chemical speciation, bioavailability, uptake, physio/chemical conditions which may pose problems, and so on.
2. The Quarantine Buoy dumpsite in the Juan de Fuca Strait adjacent to Victoria has received considerable dredged material over the last three years. At least some of this material has been found to be contaminated with certain chemical pollutants such as Hg and Cd. The site is in need of a detailed environmental examination in order to delineate the extent of the dumpsite, and to decipher environmental implications of marine disposal at this location to date.
3. Studies could be initiated to investigate the potential for possible "enhancement" of certain marine environments through the introduction of dredged materials or construction debris. Examples include the following:
 - a) dumping construction rubble at Quarantine Buoy,
 - b) recycling dredged material for marsh creation in estuaries,
 - c) disposal of organic dredgeate onto a submarine mine tailings bed to "stimulate" the sediments through mulching, thus enhancing recolonization by the benthos.
4. A detailed examination, including *in situ* field trials, is needed to evaluate the validity and accuracy of fisheries timing restrictions on clamshell dredging in areas such as the Fraser River and Burrard Inlet.
5. A field investigation/review of possible ocean dumpsites in the vicinity of Prince Rupert is required in the anticipation of major construction and port proposals, and to avoid further degradation of Porpoise Harbour.
6. A review is warranted of recent information available regarding concerns and possible disposal options, of low level radioactive wastes.

Group Discussion

The discussion which followed was wide-ranging on new topics for 1979-1980. Chemical work that was mentioned included: lead and mercury methylation with particular reference to determining whether Alberni Inlet is a "hot spot" or, in fact, "normal" with respect to heavy metals (Thompson); analysis of PCB's from the Victoria Harbour material (Macdonald); and "development of meaningful criteria for Ocean Dumping," especially techniques to recognize mobile contaminants. The latter would be a prototype study and might fit the Canadian position on dumped contaminants if it were accepted internationally (Wong).

Data on Alberni Inlet including shear phenomena near the sill, current data from the head of the basin, intrusions, and actual oxygen renewal processes, were raised as areas of deficiency by physical oceanographers (Farmer). Statistical analyses and interpretations of biological data obtained from previous years work in Alberni is on the priority list of biologists. New data on respiration due to zooplankton and phytodetritus, as well as sedimentation rates, are required to complete the oxygen budget study in Alberni. It was hoped that MacMillan Bloedel would continue its monitoring program. Other major biological problems included a necessity to summarize regional data on the impact of dumping on marine fisheries (ground fish, shrimp, and prawns), especially species with demersal or benthic eggs (Levings, Harpo, Waldichuk).

The major problem of finances was the last item for discussion with suggestions offered as to possible alternative sources for monetary support of the Ocean Dumping program.

The workshop was adjourned by Dr. Brinkhurst.

IX.

FIGURES



Figure 1. Plan view and longitudinal section of Alberni Inlet, showing sample locations for cores and oxygen budget work.

ALBERNI INLET

SAMPLING LOCATIONS OC-78-IS-001

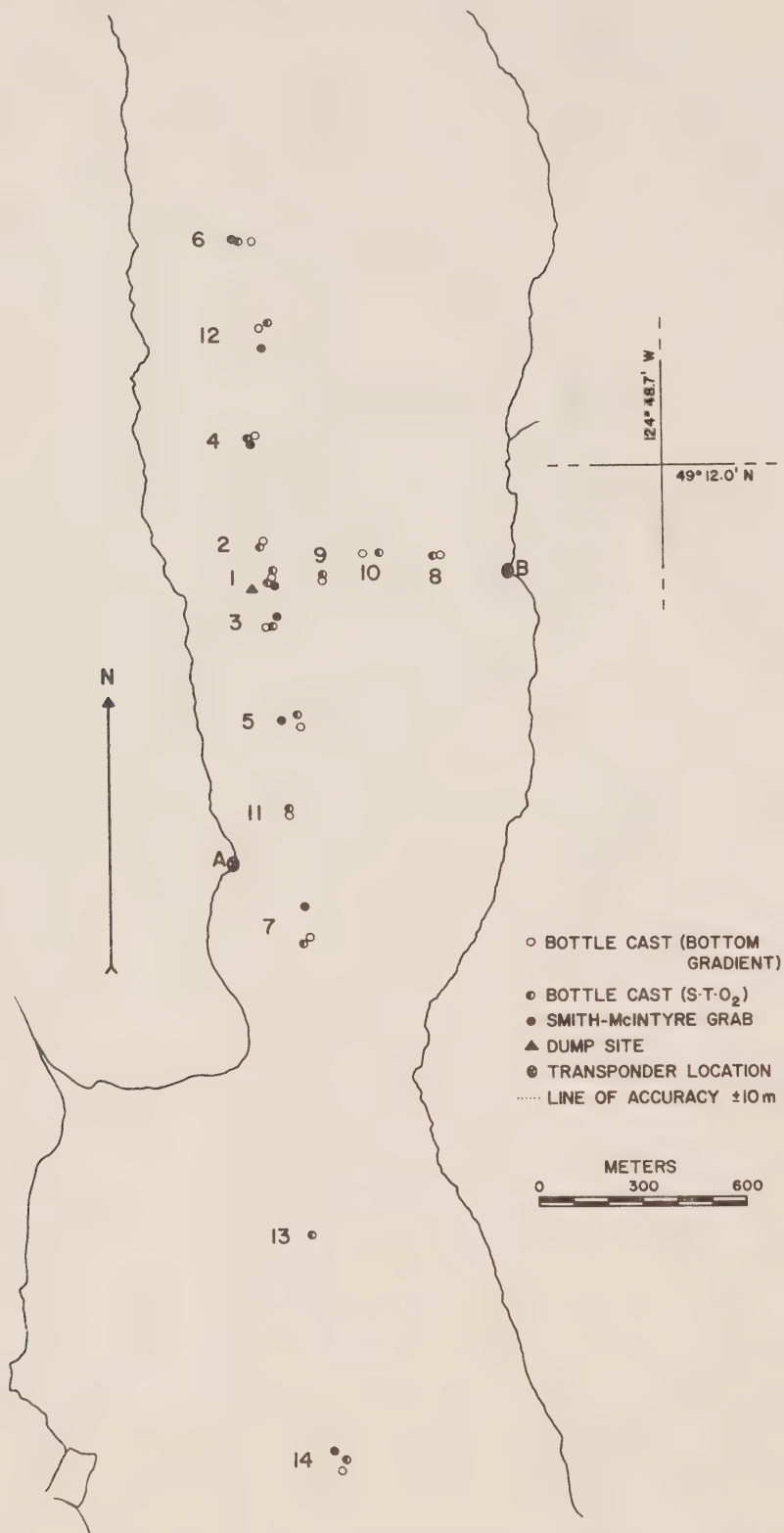


Figure 2. Station locations for water quality samples 1977, 1978.

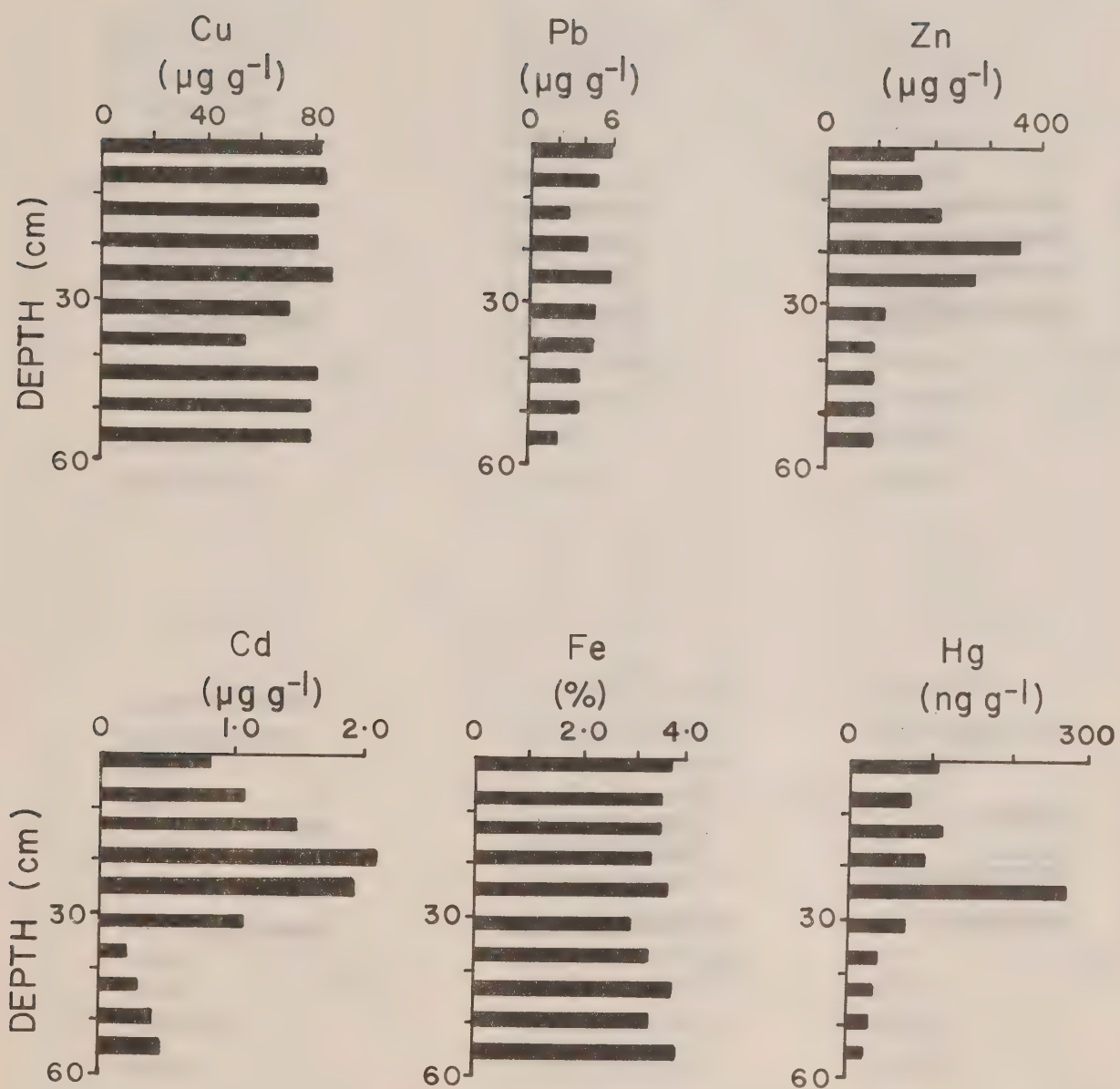


Figure 3. Metal profiles for box core 1.

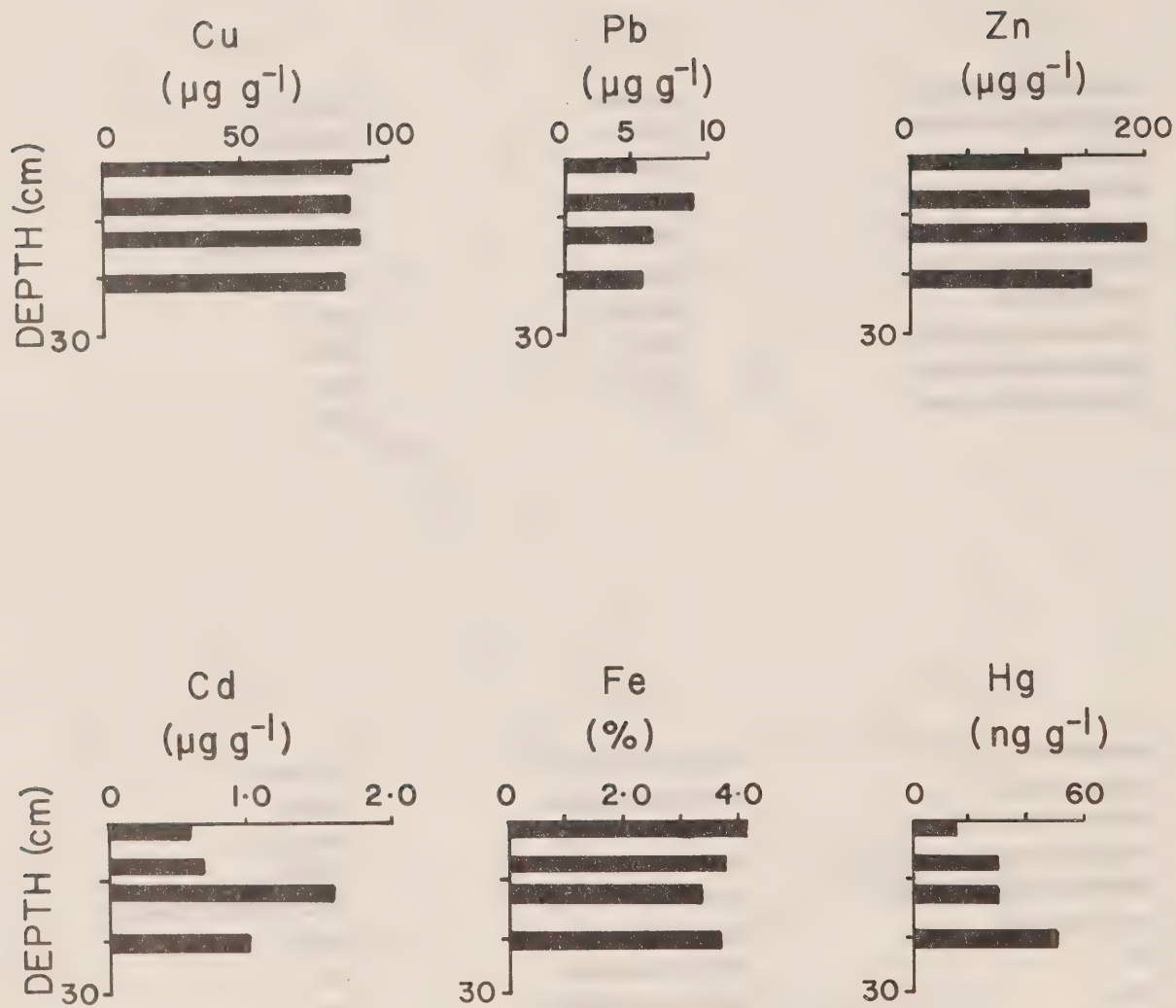


Figure 4. Metal profiles for box core 2.

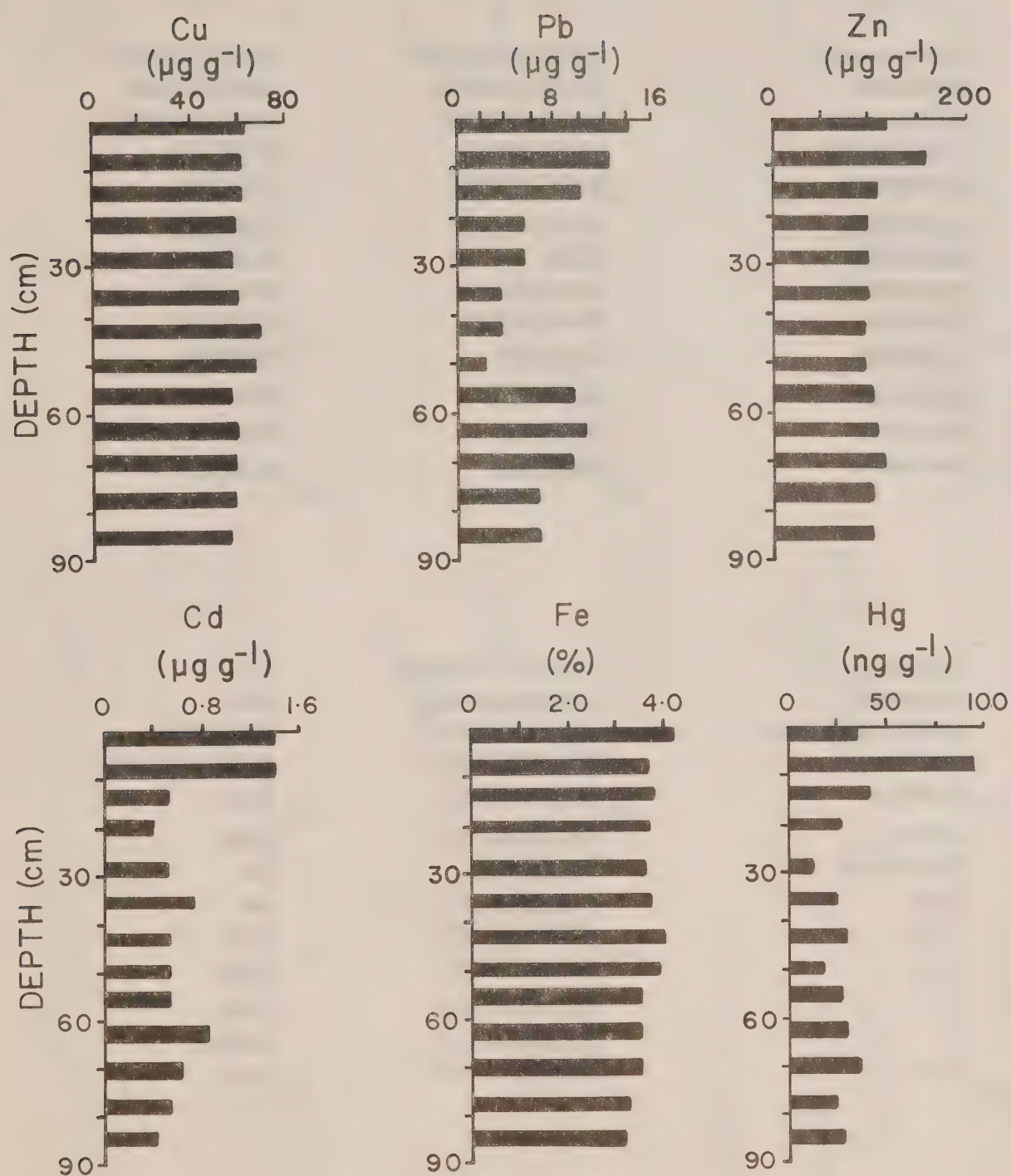


Figure 5. Metal profile for box core 3.

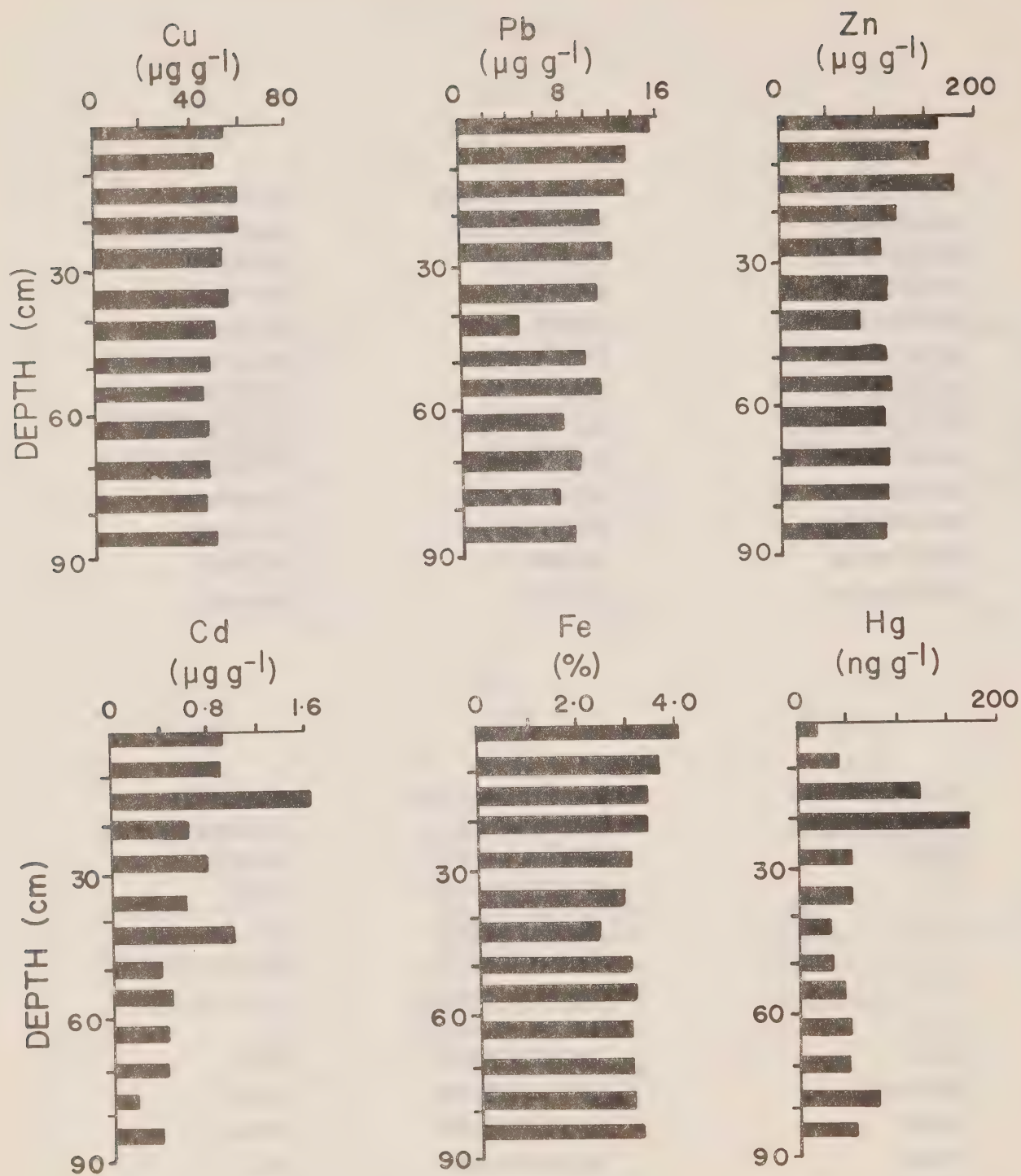


Figure 6. Metal profiles for box core 4.

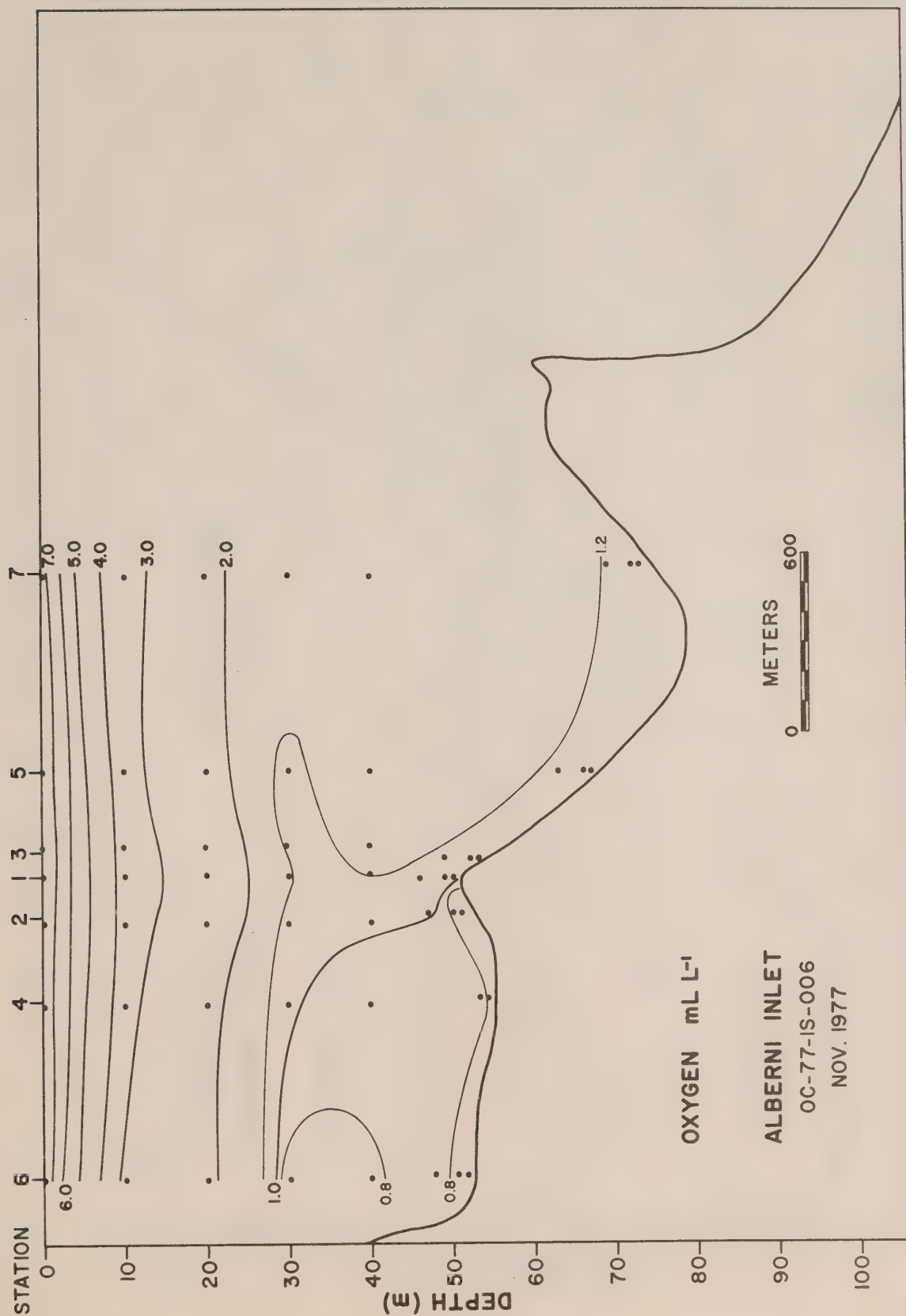


Figure 7. Vertical oxygen profile from the November cruise, 1977.

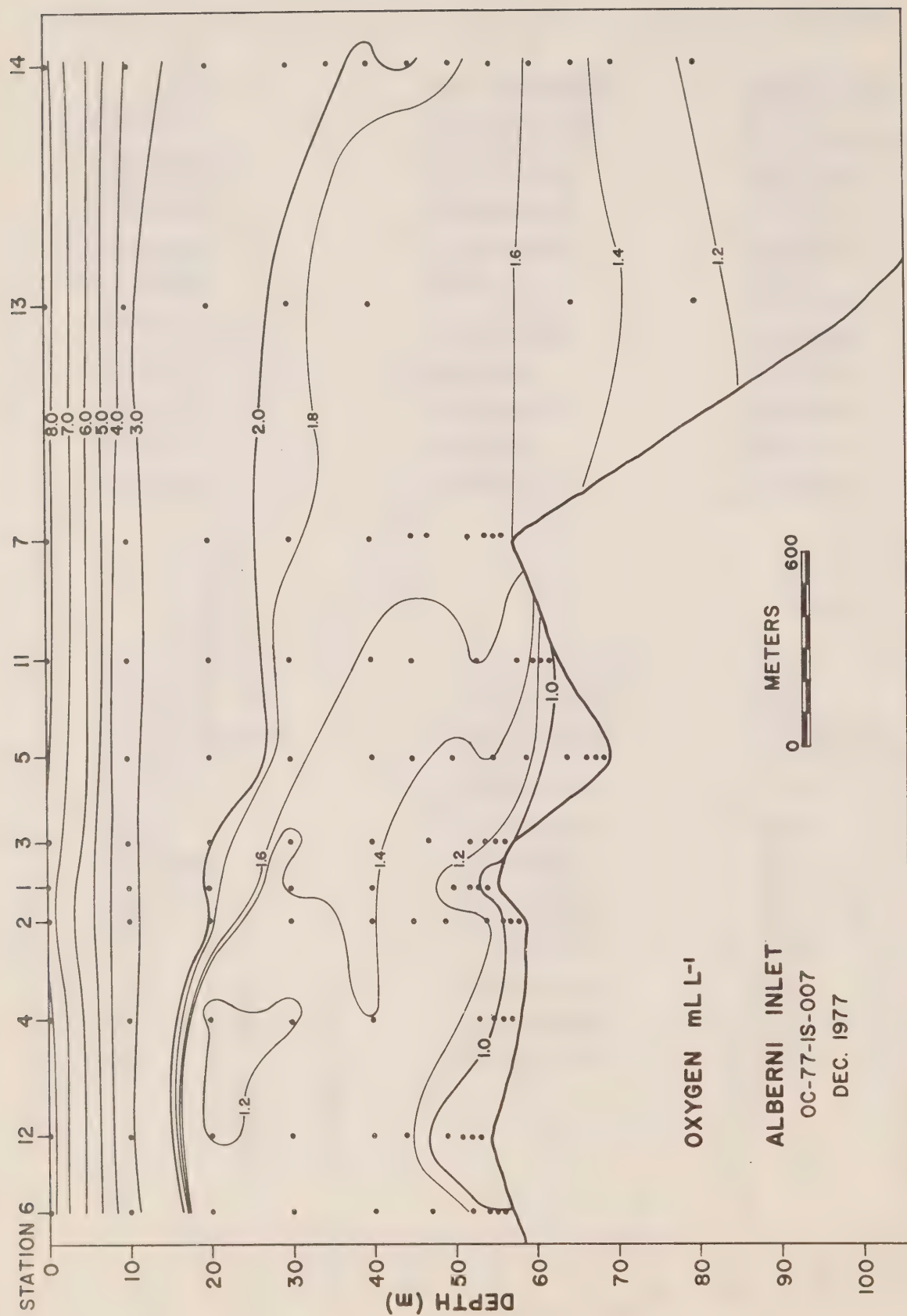


Figure 8. Vertical oxygen profile from the December cruise, 1977.

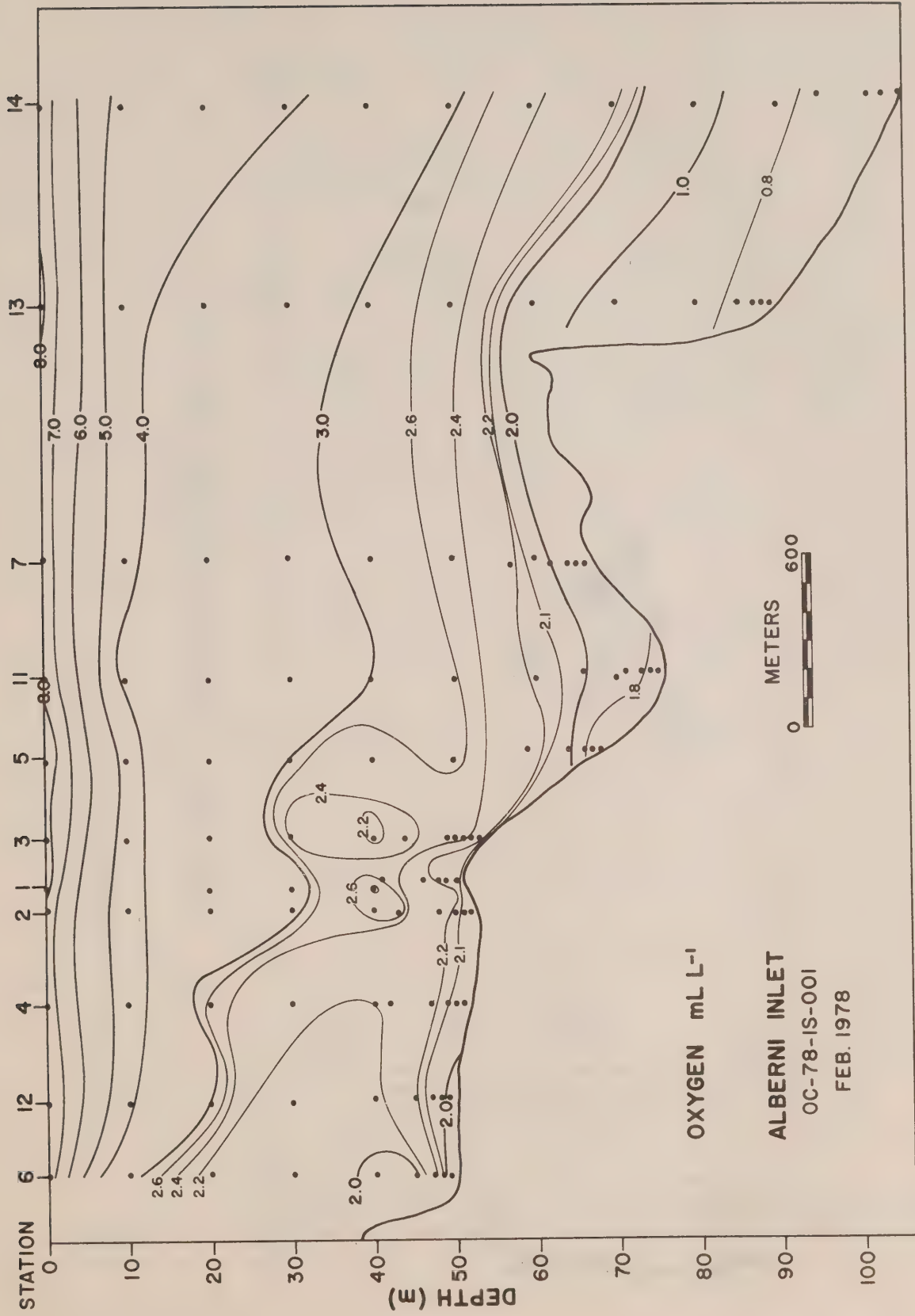


Figure 9. Vertical oxygen profile from the February cruise, 1978.

ALBERNI INLET

FEB. 1978

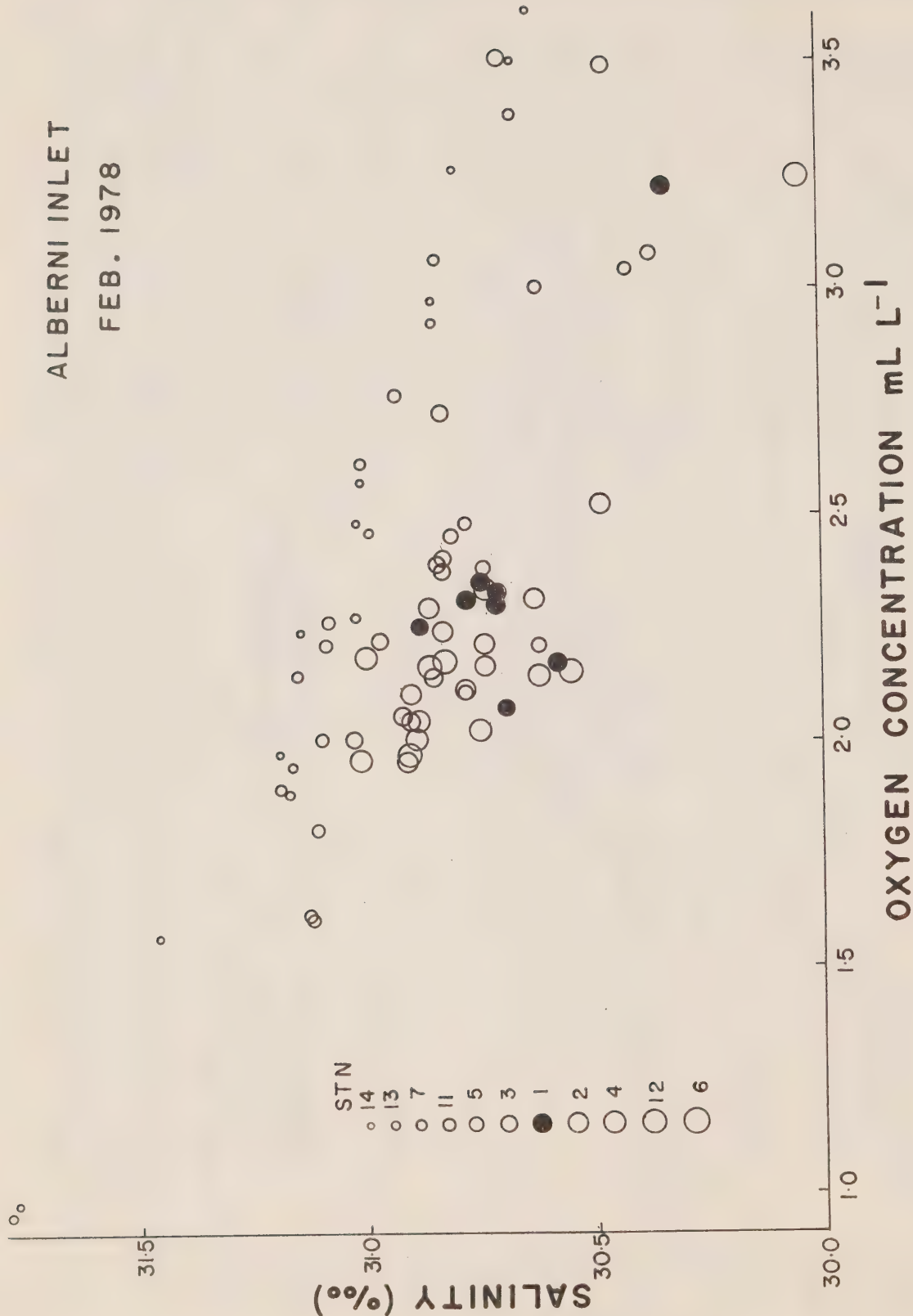
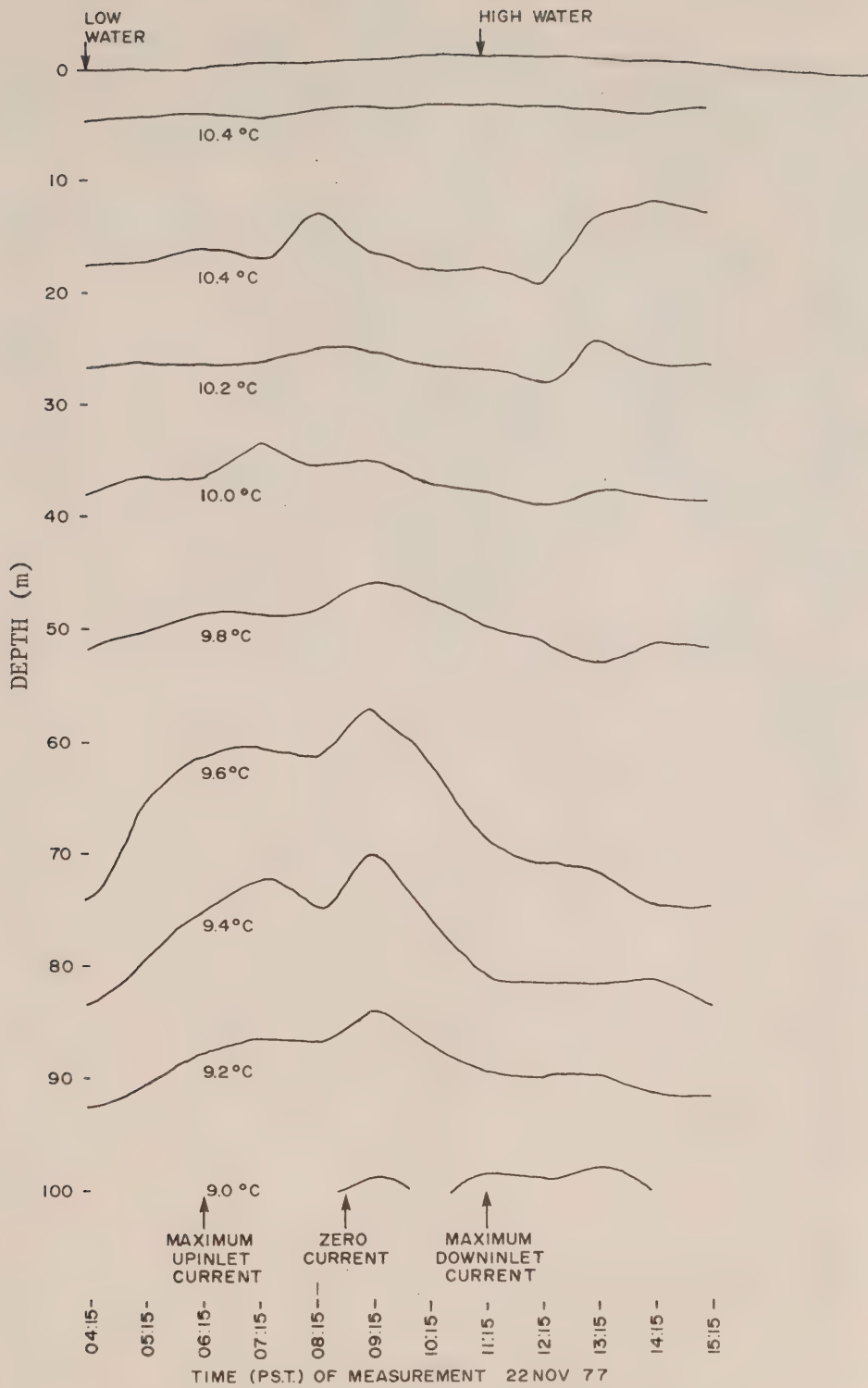


Figure 10. A salinity-oxygen diagram.



TIME AND DIRECTION OF CURRENT MAXIMUM FROM CURRENT METERS

Figure 11. Isotherms as functions of depth and time for 12 hours.

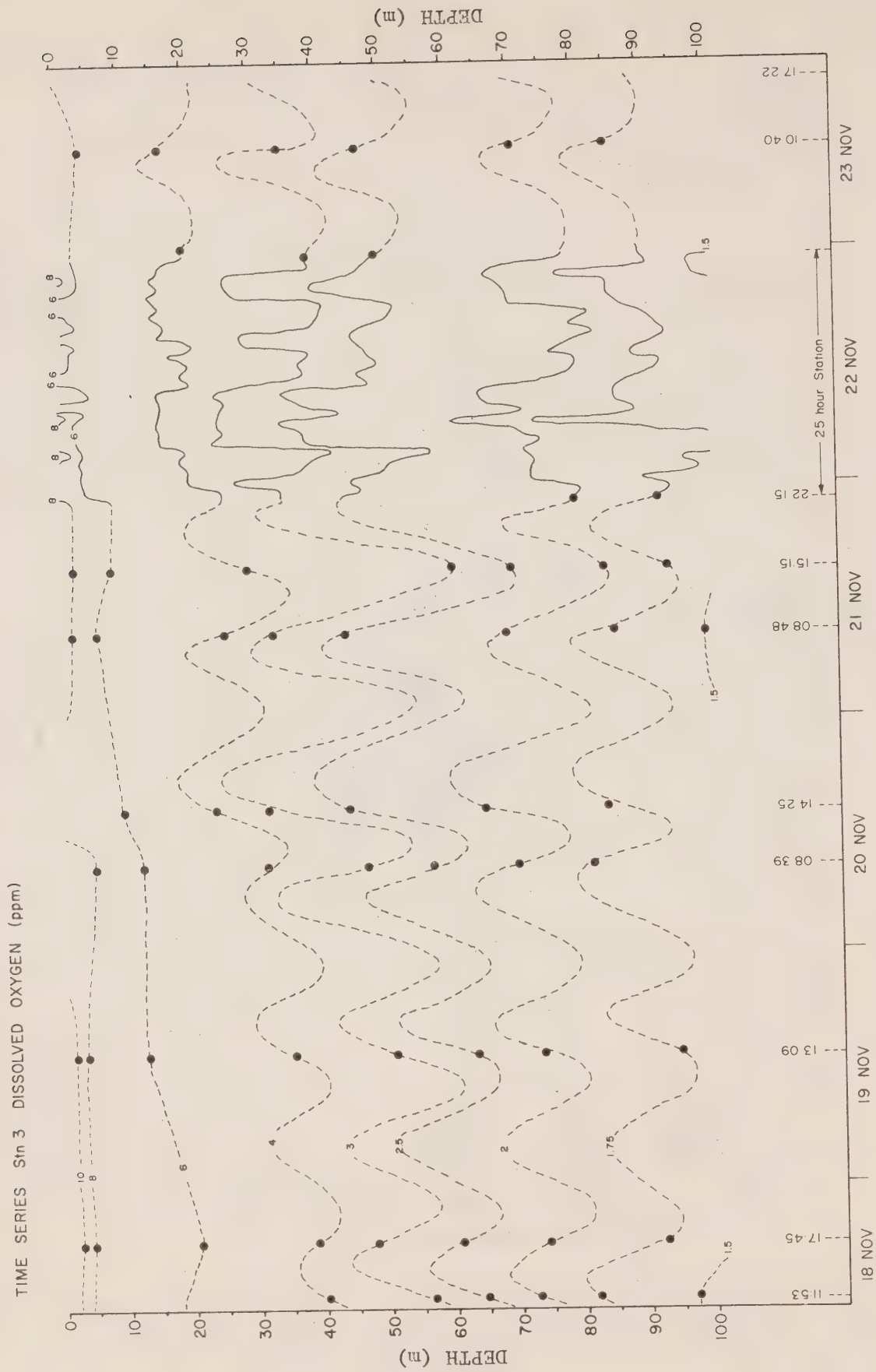


Figure 12. Isopleths of oxygen as functions of depth and time for 6 days.

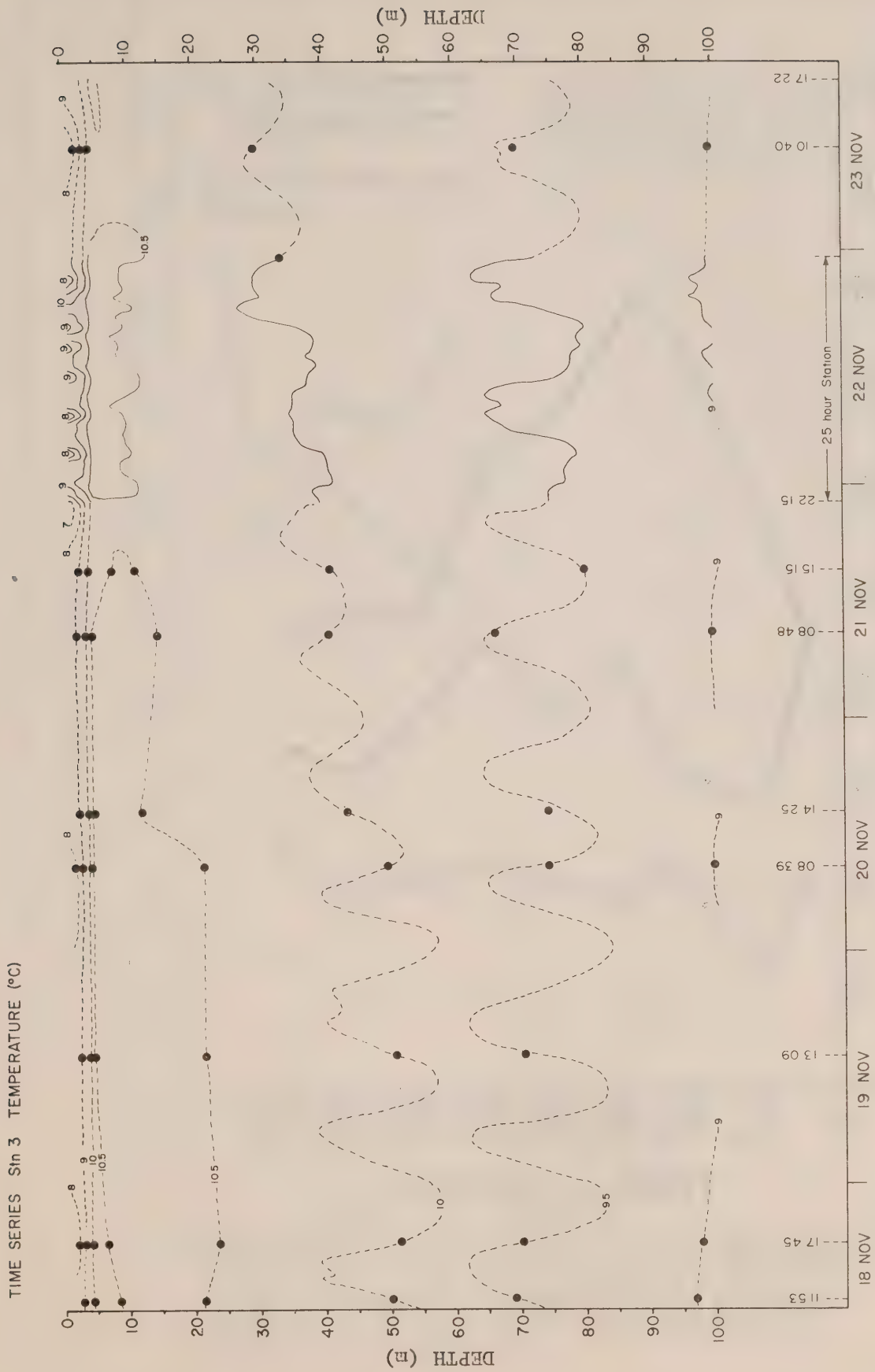


Figure 13. Isotherms as functions of depth and time for 6 days.

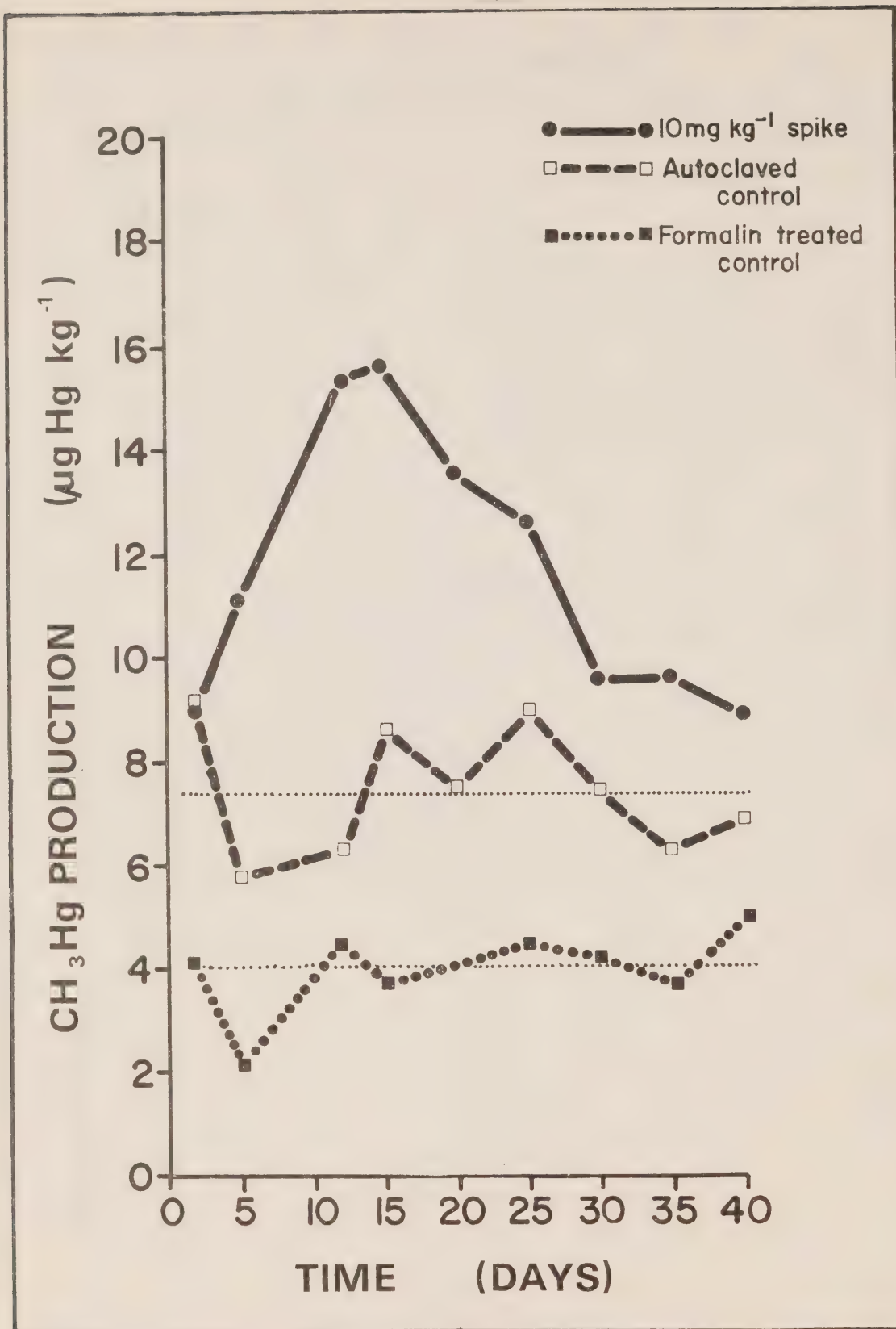


Figure 14. Methylmercury production in Alberni Inlet sediments containing 10 mg kg⁻¹ and ²⁰³Hg²⁺ under anaerobic incubation at 5°.

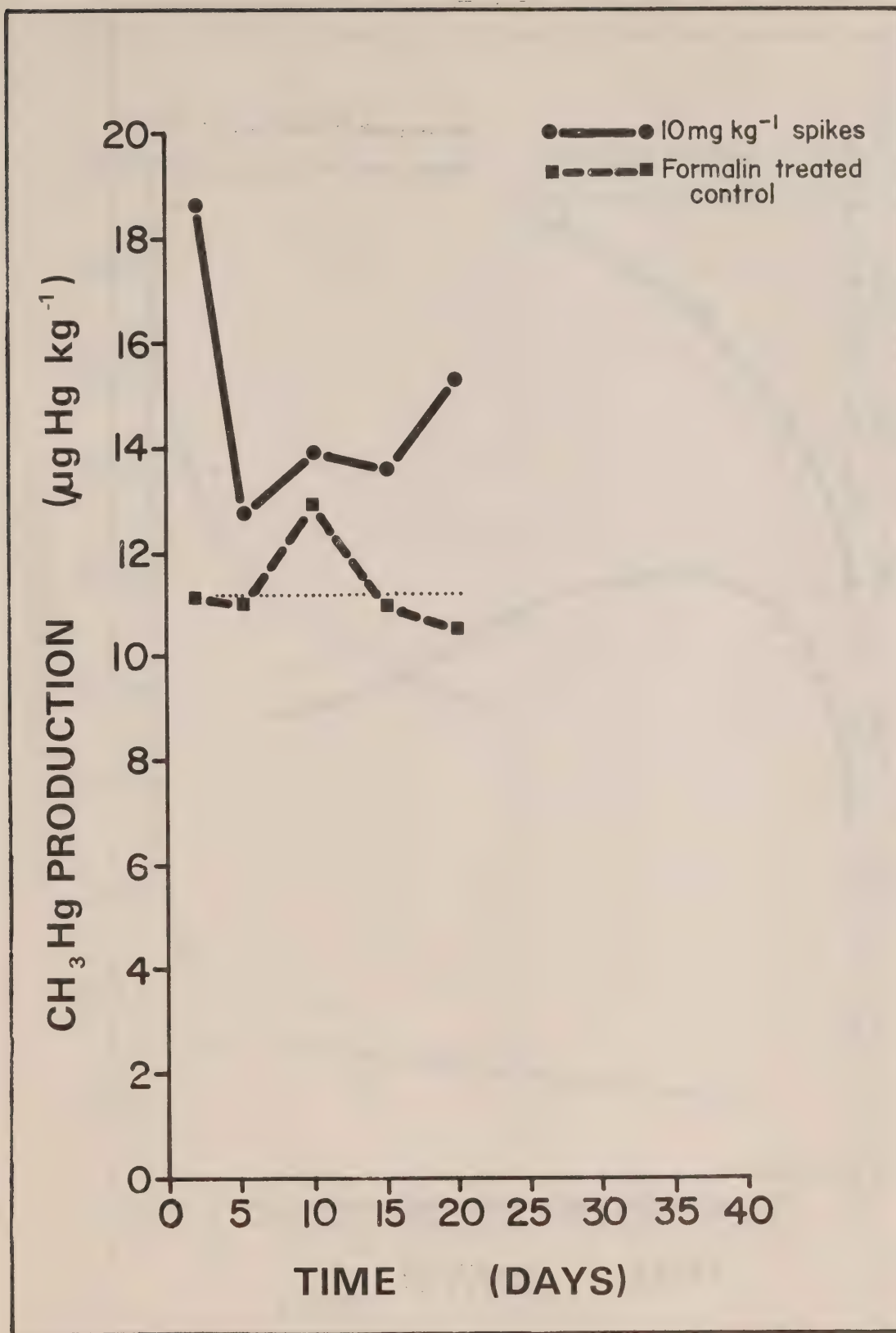


Figure 15. Methylmercury production in Alberni Inlet sediments containing 10 mg kg^{-1} as Hg^{2+} and $^{203}\text{Hg}^{2+}$ under anaerobic incubation at 5° .

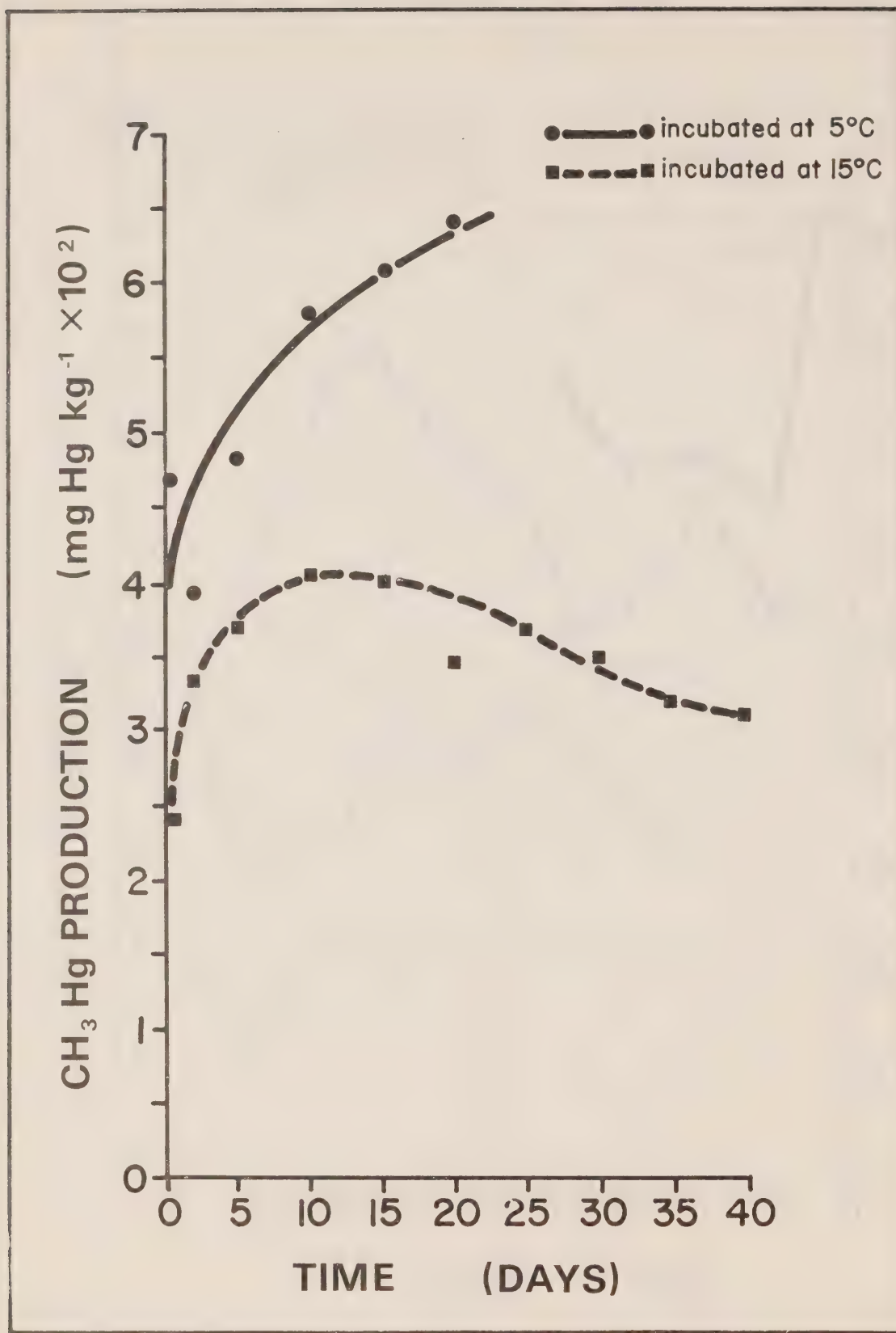


Figure 16. Methylmercury production in unspiked Alberni Inlet sediments. Anaerobic incubation at 5° and 15°.

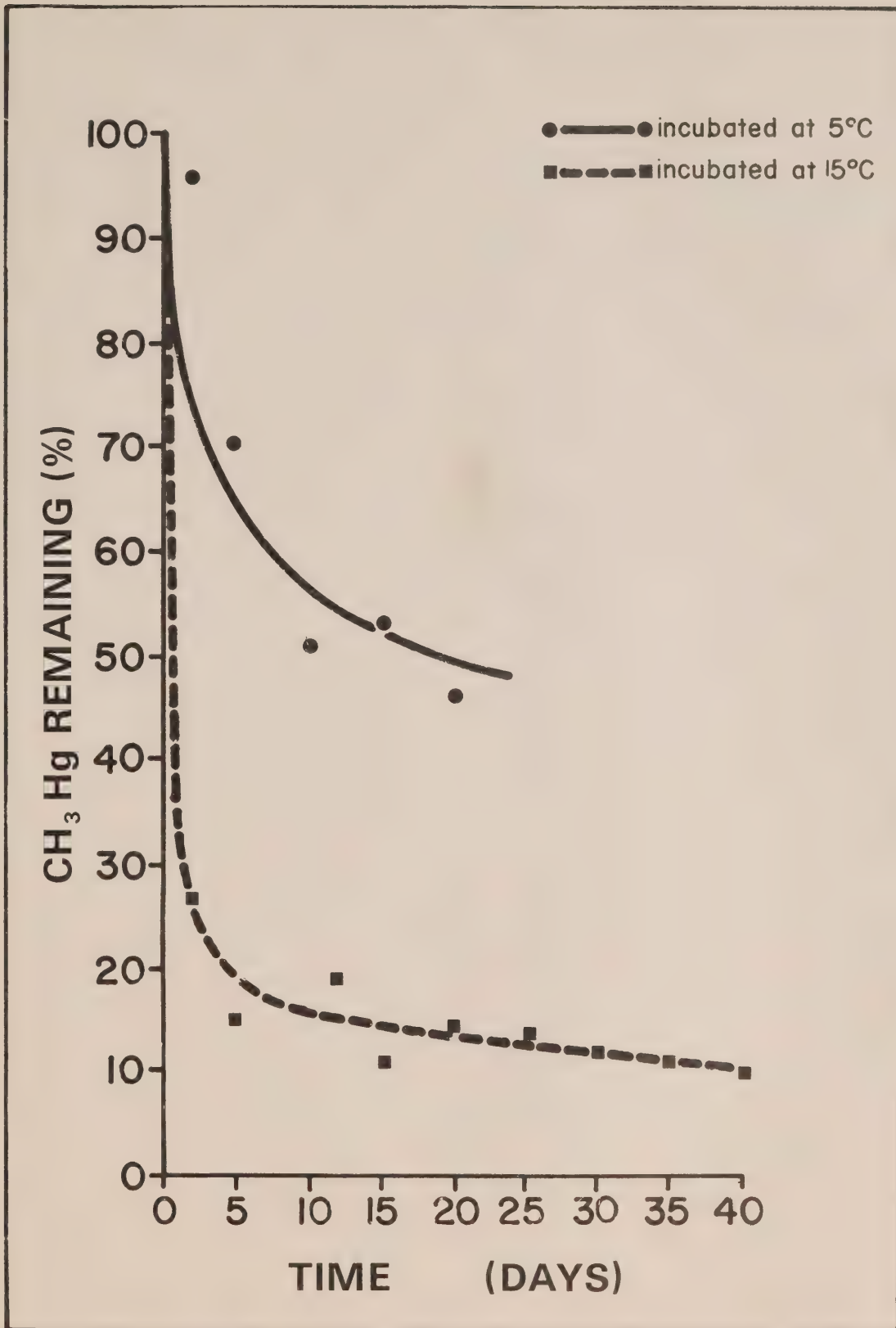


Figure 17. Decay curves for methylmercury added to Alberni Inlet sediments. Anaerobic incubation at 5° and 15°.



X.

TABLES

TABLE 1
BENTHIC O₂ DEMAND AND O₂ GRADIENTS

| STATION | O ₂ GRADIENT $\frac{(\partial c)}{(\partial z)}$ | FLUX (J) | APPARENT EDDY DIFFUSIVITY, (K _z) |
|---------|---|---|---|
| | g cm ⁻⁴ x 10 ¹⁰ | g cm ⁻² x ⁻¹ x 10 ¹⁰ | cm ² s ⁻¹ $\left(-J/\frac{\partial c}{\partial z}\right)$ |
| 1 | - 7.07 | 10.3 | 1.46 |
| 2 | -10.2 | 3.6 | 0.35 |
| 3 | - 1.29 | 6.1 | 4.73 |
| 4 | - 5.57 | 3.9 | 0.70 |
| 5 | -14.1 | - | - |
| 6 | -22.6 | 12.8 | 0.57 |
| 7 | - 3.4 | 6.6 | 1.96 |
| 8 | - | - | - |
| 9 | - 1.54 | - | - |
| 10 | -24.2 | - | - |
| 11 | - 2.07 | - | - |
| 12 | - 3.50 | 1.39 | 0.39 |
| 13 | - 3.60 | - | - |
| 14 | - 0.57 | 6.7 | 11.8 |

TABLE 2

COMPARISON OF TERMS USED IN THE CONSERVATION EQUATION

| TERM | de LANGE BOOM, 1977 | THIS STUDY, 1978 |
|---|---|--|
| $\frac{\partial c}{\partial t}$ | $- 2.5 \times 10^{-7}$ to $- 1.5 \times 10^{-7}$ mg L ⁻¹ sec ⁻¹ | $- 2.5 \times 10^{-7}$ to $- 1.5 \times 10^{-7}$ mg L ⁻¹ sec ⁻¹ |
| u | 20.0 cm sec ⁻¹ | < $- 1.0$ cm sec ⁻¹ |
| $\frac{\partial c}{\partial x}$ | 1.3×10^{-6} mg L ⁻¹ cm ⁻¹ | 1.3×10^{-6} mg L ⁻¹ cm ⁻¹ |
| w | $\leq 10^{-4}$ cm sec ⁻¹ | $\leq 10^{-4}$ cm sec ⁻¹ |
| $\frac{\partial c}{\partial z}$ | 2.0×10^{-4} mg L ⁻¹ cm ⁻¹ | 2.0×10^{-4} mg L ⁻¹ cm ⁻¹ |
| $K_z \frac{\partial^2 c}{\partial z^2}$ | 3.5×10^{-7} mg L ⁻¹ sec ⁻¹ | 1.0×10^{-8} mg L ⁻¹ sec ⁻¹ |
| $S_R + S_P$ | 0 mg L ⁻¹ sec ⁻¹ | 0 mg L ⁻¹ sec ⁻¹ |
| $S_D + S_B$ | 8.3×10^{-8} mg L ⁻¹ sec ⁻¹ | -- |
| S_B | -- | 9.0×10^{-8} mg sec ⁻¹ L ⁻¹ - 32×10^{-8} mg sec ⁻¹ L ⁻¹ |
| S_D | | ? |

TABLE 3
SUMMARY OF BENTHIC SAMPLING EFFORT

| DATES | TRIP NO. | WORK ¹ | COMMENTS |
|---------------------------|----------|--------------------|-----------------------------|
| November 15 to 17, 1977 | 1 | Grab sampling | |
| November 28 to December 1 | 2 | Grab, respirometer | |
| December 13 | 3 | Grab sampling | |
| December 20, 21 | 4 | Grab, respirometer | |
| January 25, 26, 1978 | 5 | Grab, respirometer | |
| February 21 | 6 | Grab, respirometer | |
| March 9, 10 | 7 | Grab sampling | |
| March 21 to 23 | 8 | Grab, respirometer | Dumpsite not sampled |
| April 20, 21 | 9 | Grab, respirometer | Billed to MacMillan Bloedel |
| May 18, 19 | 10 | Grab, respirometer | Billed to MacMillan Bloedel |
| July 4 to 6 | 11 | Grab, respirometer | |
| July 31 to August 2 | 12 | Grab, respirometer | |
| August 28 to 30 | 13 | Grab, respirometer | |

¹
On each sampling trip, data on sediments (grain size, C, N, LOI) and water (T, S, D.O.) characteristics (1 m from bottom) are also obtained.

TABLE 4
BENTHIC *IN SITU* RESPIRATION
(Control station only)

| DATE | AMBIENT (mg L ⁻¹ O ₂) | TEMPERATURE (°C) | CONSUMPTION (mg O ₂ m ⁻² hr ⁻¹) |
|----------|---|---------------------|--|
| January | 1.9 | 9.6 | 0.167 |
| February | 1.9 | 9.5 | 0.376 |
| March | 4.2 | 9.6 | 0.367 |
| April | 4.1 | 9.5 | 0.591 |
| May | 5.0 | 9.8 | 0.745 |
| July | 5.1 | 9.3 | 0.200 |
| August | 3.9 | 9.1 | 0.132 |

TABLE 5
CH₃Hg, TOTAL MERCURY, MOISTURE AND
CARBON CONTENT OF GRAB SAMPLES

| SAMPLE | %H ₂ O | %C | CH ₃ Hg (μg Hg kg ⁻¹) | TOTAL Hg (mg kg ⁻¹) |
|--|-------------------|--------------|--|------------------------------------|
| November 1977 | 70.5 | 7.86 7.84 | 19.8 (3.5) ^a 28.1 (4.6) ^a | 0.57 0.61 |
| February 1978 | 69.5 | 7.59 7.54 | 46.2 (12.2) ^a 48.1 (11.7) ^a | 0.38 0.41 |
| ^a Values in parentheses are percent of total as CH ₃ Hg. | | | | |

TABLE 6

SUMMARY OF ANALYTICAL RESULTS OF VICTORIA HARBOUR DREDGE SPOILS

| ANALYSIS | MEAN† | RANGE† | | |
|---|-------|--------|---|-------|
| Iron % | 2.63 | 1.80 | - | 3.55 |
| Copper mg kg ⁻¹ | 110. | 44. | - | 540. |
| Lead mg kg ⁻¹ | 260. | 24. | - | 2000. |
| Zinc mg kg ⁻¹ | 243. | 84. | - | 465. |
| Cadmium mg kg ⁻¹ | 1.28 | 0.1 | - | 2.4 |
| Chromium mg kg ⁻¹ | 107. | 70. | - | 350. |
| Mercury mg kg ⁻¹ | 1.90 | 0.26 | - | 3.98 |
| Arsenic mg kg ⁻¹ | 7.6 | 4. | - | 37. |
| % Organic Carbon | 3.56 | 0.61 | - | 6.8 |
| O ₂ Uptake mg kg ⁻¹ | 440. | 120. | - | 1600. |
| % Moisture | 49.7 | 27.3 | - | 65.9 |
| *EOM mg kg ⁻¹ | 1890. | 400. | - | 6800. |
| **SAP EOM mg kg ⁻¹ | 1470. | <100. | - | 5600. |
| ***F ₁ mg kg ⁻¹ | 426.6 | 20. | - | 3290. |
| ****F ₂ mg kg ⁻¹ | 249.9 | ND | - | 870. |
| *****F ₃ mg kg ⁻¹ | 118.3 | ND | - | 630. |

† All analyses are on a dry weight basis.

Our data were obtained 28/10/77; 18/11/77; 30/11/77; 15/12/77; 6/1/78 (grab samples).

DEFINITIONS

- *EOM - organic material extractable by an organic solvent (1:1 methanol:benzene)
- **SAPONIFIED EOM - organic material remaining after non-hydrocarbons (esters, animal fats) are removed
- ***F₁ - aliphatic and alicyclic (saturated) fraction of hydrocarbons
- ****F₂ - fraction consisting largely of 2-3 ring aromatic hydrocarbons (naphthalenes, anthracenes)
- *****F₃ - fraction consisting largely of polynuclear aromatic hydrocarbons

TABLE 7

RESULTS OF STATISTICAL ANALYSIS OF THE PERCENTAGE
OF VARIATION DUE TO DIFFERENT CAUSES

| Measurement | Variation accounted for within sub- samples from the <u>same</u> grab sample on the barge | Variation accounted for between samples taken from the <u>same</u> barge | P< | Variation accounted for between samples taken from <u>different</u> barges | P< |
|---------------------|---|---|-------|---|-------|
| | (In %) | (In %) | | (In %) | |
| Iron | 27.4 | 63.2 | .001 | 9.4 | .001 |
| Copper | 43.3 | 27.4 | .092† | 29.3 | .001 |
| Lead | 53.3 | 32.6 | .114† | 14.1 | .002 |
| Zinc | 13.3 | 48.9 | .001 | 37.8 | .001 |
| Cadmium | 11.6 | 55.3 | .001 | 33.1 | .001 |
| Chromium | 49.0 | 41.9 | .009 | 9.1 | .017 |
| Mercury | 18.7 | 45.9 | .001 | 35.4 | .001 |
| Arsenic | 61.7 | 31.0 | .290† | 7.3 | .095† |
| % Organic Carbon | 19.0 | 37.6 | .001 | 43.4 | .001 |
| Oxygen Uptake | 48.7 | 36.0 | .032 | 15.3 | .001 |
| % Moisture | 15.3 | 41.0 | .001 | 43.7 | .001 |
| *EOM | 32.6 | 45.0 | .001 | 22.4 | .001 |
| **SAP EOM | 39.5 | 41.2 | .001 | 19.3 | .001 |
| ***F ₁ | 63.3 | 32.7 | .257† | 4.0 | .354† |
| ****F ₂ | 63.3 | 25.9 | .544† | 10.8 | .024 |
| *****F ₃ | 62.9 | 31.2 | .301† | 5.9 | .175† |

† Not significant at 95% level

DEFINITIONS

As for Table 6.

TABLE 8

RESULTS OF CHEMICAL ANALYSIS PERFORMED BY WILLIS, CUNLIFFE, TAIT &
COMPANY LTD. FOR EPS PERMITS TO DUMP

| CHEMICAL ANALYSIS | DECEMBER 21, 1977 | JANUARY 4, 1978 |
|-------------------------------|----------------------|--------------------|
| Copper mg kg ⁻¹ | 93.7 | 100.0 |
| Lead mg kg ⁻¹ | 242.0 | 256.0 |
| Zinc mg kg ⁻¹ | 234.0 | 253.0 |
| Cadmium mg kg ⁻¹ | 2.6 | 2.5 |
| Mercury mg kg ⁻¹ * | 0.65 | 0.81 |
| PCBs mg kg ⁻¹ | 0.39 | 0.084 |

* All analysis are on a dry weight basis, except Mercury: it was measured as wet weight (dry weight = ~~wet~~ wet weight x 2 or an average of 1.5 mg kg⁻¹ Hg dry weight).

TABLE 9

A COMPARISON BETWEEN GRAB-SAMPLE SURVEY AND BARGES

| ANALYSIS | PRE-DREDGE | BARGE 1 | BARGE 2 | BARGE 3 | BARGE 4 |
|---------------------|------------|---------|---------|---------|---------|
| Iron | 2.57 | 2.46 | 2.65 | 2.79 | 2.63 |
| Copper | 147.9 | 143.1 | 93.0 | 70.6 | 96.9 |
| Lead | 306.8 | 379.8 | 201.7 | 178.1 | 231.2 |
| Zinc | 316.2 | 281.9 | 223.0 | 162.4 | 232.4 |
| Cadmium | 1.38 | 1.76 | 1.20 | 0.77 | 1.27 |
| Chromium | 127.1 | 137.9 | 119.1 | 103.6 | 116.7 |
| Mercury | 1.79 | 2.79 | 1.63 | 1.31 | 1.69 |
| Arsenic | 8.8 | 8.1 | 7.8 | 6.2 | 6.9 |
| % Organic Carbon | 4.45 | 4.89 | 2.60 | 2.46 | 3.24 |
| Oxygen Uptake | 530. | 440. | 30. | 42. | 51. |
| % Moisture | 56.4 | 57.5 | 44.5 | 44.1 | 45.9 |
| *EOM | 2870. | 2170. | 1590. | 1170. | 1640. |
| **SAP EOM | 2200. | 1670. | 1400. | 740. | 1370. |
| ***F ₁ | 544. | 440. | 490. | 293. | 480. |
| ****F ₂ | 244. | 333. | 305. | 170. | 198. |
| *****F ₃ | 155. | 120. | 144. | 82. | 91. |

All analyses reported as mg kg⁻¹ (dry weight basis) except where otherwise noted.

DEFINITIONS

As for Table 6.

XI.

APPENDICES

APPENDIX I

OCEAN DUMPING WORKSHOP ATTENDANCE LIST

R. O. Brinkhurst, Ocean Ecology Laboratory, I.O.S. (Workshop Chairman)
C. D. Levings, P.E.I., West Vancouver (Workshop Secretary)

E. P. Anderson, Dobrocky SEATECH Ltd., Victoria
P. Berrang, Seakem Oceanography Ltd., Victoria
W. R. Buckingham, Dobrocky SEATECH Ltd., Victoria
S. C. Byers, Dobrocky SEATECH Ltd., Victoria
J. A. Crerar, Beak Consultants Ltd., Richmond
P. Doyle, Chemex Labs Ltd., Vancouver
W. English, Plumper Ocean Projects
D. M. Farmer, Coastal Zone Oceanography, I.O.S.
R. Harbo, D.F.O., Vancouver
R. A. W. Hoos, E.P.S., Vancouver
A. J. Jordan, Beak Consultants Ltd., Vancouver
J. M. Landucci, E.P.S., West Vancouver
R. W. Macdonald, Ocean Chemistry, I.O.S.
D. Morse, Chemex Labs Ltd., Vancouver
S. Nelles, D.F.O., Vancouver
W. D. Paton, Ocean Chemistry, I.O.S.
G. R. Smith, I.O.S. (Industrial Liaison Officer)
P. Thomas, Econotech Services Ltd., New Westminster
J. A. J. Thompson, Ocean Chemistry, I.O.S.
D. Timun, Cantest Ltd., Vancouver
G. Vigers, E.V.S. Consultants, North Vancouver
M. Waldichuk, D.F.O., West Vancouver
I. T. Webster, Dobrocky SEATECH Ltd., Victoria
C. S. Wong, Ocean Chemistry, I.O.S.
R. Young, MacMillan Bloedel Ltd., Vancouver

APPENDIX II

1977-78 CONTRACT MANUSCRIPT REPORTS

A. Biology

Ref. DSS File No. 08SS. KF833-7-1210

\$27,000.00

Marine biological sampling and observations of temporal changes in benthic communities and benthic respiration at a dumpsite in Port Alberni.

Scientific Authority: C. D. Levings (P.E.I.)
R. O. Brinkhurst (I.O.S.)

Contractor: Beak Consultants Ltd.
Suite 602 - 1550 Alberni Street
Vancouver, B. C. V6G 1A5

Contract Amendment to OSS76-02122

RN KF832-6-0873-FC, 2-03-3140-711-0432

\$ 6,200.00

(Addition to 1976-77 contract to study leachates from dredge spoils containing wood waste.)

Additional sampling and analysis required.

Scientific Authority: H. Rogers (P.E.I.)

Contractor: Econotech Services Ltd.
852 Derwent Way
Annacis Island
New Westminster, B. C.

1977-78 Contracts (continued)

B. Chemistry

Ref. DSS File No. 08SS. KF833-7-1271 \$ 9,000.00

Collection and analysis of seawater and undisturbed sediment cores in Alberni Inlet.

Scientific Authority: R. W. Macdonald (I.O.S.)

Contractor: Chemex Labs Ltd.
212 Brooksbank Avenue
North Vancouver, B. C. V7J 2C1

Ref. DSS File No. 08SS. KF833-7-1269 \$ 5,500.00

Variability in analytical results on dredged spoils and marine sediment in connection with the validity of presently prescribed criteria.

Scientific Authority: R. W. Macdonald (I.O.S.)

Contractor: Chemex Labs Ltd.
212 Brooksbank Avenue
North Vancouver, B. C. V7J 2C1

Ref. DSS File No. 08SS. KF833-7-1277 \$ 4,000.00

Analytical support for a study of mercury biotransformation in anoxic estuarine sediments.

Scientific Authority: J. A. J. Thompson (I.O.S.)

Contractor: Willis, Cunliffe, Tait & Co. Ltd.
827 Fort Street
Victoria, B. C. V8W 1H6

1977-78 Contracts (continued)

C. Physics

Ref. DSS File No. 08SS. KF833-7-1367 \$22,000.00

Oxygen budget studies in Alberni Inlet.

Scientific Authority: W. H. Bell (I.O.S.)

Contractor: Dobrocky SEATECH Ltd.
135 Kingston Street
Victoria, B. C. V8V 1V4

D. Administration

Ref. DSS File No. 08SS. KF832-7-1004 \$ 6,200.00

To review and record activities relating to ocean dumping on the west coast.

Scientific Authority: R. O. Brinkhurst

Contractor: K. E. Conlan

Appendix III
1978-79 CONTRACTS

A. Biology

1. Ref. DSS File No. 08SS. KF833-7-1210 \$27,000.00
2. Ref. DSS File No. 08SB. KF833-8-0248 \$29,010.00

Marine biological sampling and observations of temporal changes in benthic communities and benthic respiration at a dumpsite in Port Alberni.

Scientific Authority: C. D. Levings (P.E.I.)

Contractors:

1. Beak Consultants Ltd.
2. Dobrocky SEATECH Ltd.

Ref. DSS File No. 08SB. KF833-8-0248
Amendment \$ 1,372.00

(a) Review literature on the reproductive ecology of selected invertebrates from a dumpsite in Alberni Inlet.

(b) Verify identification of invertebrates performed by others working at Alberni Inlet and compare identification with current studies.

Scientific Authority: C. D. Levings (P.E.I.)

Contractor: Dobrocky SEATECH Ltd.

B. Chemistry

Ref. DSS File No. 07SB. KF833-8-0590 \$ 6,300.00

Analysis of sediment samples for polychlorinated biphenyls.

Scientific Authority: R. W. Macdonald (I.O.S.)

Contractor: Seakem Oceanography Ltd.

1978-79 Contracts (continued)

B. Chemistry - continued

Ref. DSS File No. 07SB. KF833-8-0591 \$ 7,358.00

Determination of the lead methylating capacity of Pacific coastal marine sediments.

Scientific Authority: J.A.J Thompson (I.O.S.)

Contractor: Beak Consultants Ltd.

Ref. DSS File No. 07SB. KF833-8-0592-1 \$10,421.15

Development of a meaningful criteria for ocean disposal of dredged or sedimentary material - Part I.

Scientific Authority: R. W. Macdonald (I.O.S.)

Contractor: Can Test Ltd.

Ref. DSS File No. 07SB. KF833-8-0592-2 \$10,241.25

Development of a meaningful criteria for ocean disposal of dredged or sedimentary material - Part II.

Scientific Authority: R. W. Macdonald (I.O.S.)

Contractor: Seakem Oceanography Ltd.

Ref. DSS File No. 08SB. KF833-8-1577 \$ 1,377.00

Analyses of samples of marine holothurian, *Molpadia intermedia* for the determination of copper, zinc and cadmium.

Scientific Authority: J.A.J. Thompson (I.O.S.)

Contractor: Can Test Ltd.

1978-79 Contracts (continued)

C. Physics

Ref. DSS File No. 07SB. KF833-8-0594 \$ 7,980.60

Examination of the variability of upwelling on the West Coast of Vancouver Island and its relationship to the flushing of Alberni Inlet.

Scientific Authority: W. N. Bell (I.O.S.)

Contractor: Beak Consultants Ltd.

Ref. DSS File No. 07SB. KF833-8-0593 \$ 4,402.00

Examination of evidence for an internal tide in Alberni Inlet.

Scientific Authority: W. N. Bell (I.O.S.)

Contractor: Seakem Oceanography Ltd.

D. Administration

Ref. DSS File No. 07SB. KF833-8-0459 \$ 8,435.00

Support for the West Coast dumping program.

Scientific Authority: R. O. Brinkhurst (I.O.S.)

Contractor: Dobrocky SEATECH Ltd.

For H.Q. Office \$ 2,500.00

Annotated bibliography of Canadian papers and reports bearing on Ocean Dumping. Part II: Pacific Region.

Scientific Authority: D.S. Bezanson (Bedford Institute of Oceanography)

Contractor: Catherine Moyse

APPENDIX IV

LOCATIONS OF SCIENTIFIC AUTHORITIES

1979

E.P.S.

Environmental Protection Service
Kapilano 100, Park Royal
West Vancouver, B. C. V7T 1A2

D.F.O.

Department of Fisheries and Oceans
Habitat Protection Directorate
1090 West Pender Street
Vancouver, B. C. V6E 2P1

I.O.S.

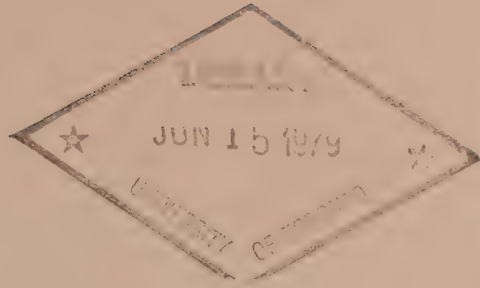
Institute of Ocean Sciences
Department of Fisheries and Oceans, Patricia Bay
P. O. Box 6000
9860 West Saanich Road
Sidney, B. C. V8L 4B2

P.E.I.

Pacific Environment Institute
Department of Fisheries and Oceans
4160 Marine Drive
West Vancouver, B. C. V7V 1N6

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**OCEANOGRAPHIC OBSERVATIONS
AT OCEAN STATION P
16 June - 2 August 1978
Volume 92**

**INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY
Sidney, B.C.**



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Institute of Ocean Sciences

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V8L 4B2

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Sidney, B.C.

1979

This is a manuscript which has received only limited circulation. On citing this report in a bibliography, the title should be followed by the words "UNPUBLISHED MANUSCRIPT" which is in accordance with accepted bibliographic custom.

ABSTRACT

Physical, chemical and biological oceanographic observations are made from the weathership at Ocean Weather Station Papa, and between Esquimalt and Station Papa, on a routine continuing basis. Physical oceanography data only are shown, including surface observations and profiles obtained with bottle casts and conductivity-temperature-pressure instruments.

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INTRODUCTION

Canadian operation of Ocean Weather Station P (Latitude $50^{\circ}00'$ N, Longitude $145^{\circ}00'$ W) was inaugurated in December, 1950. The station is occupied primarily to make meteorological observations of the surface and upper air and to provide an air-sea rescue service. The station is manned by two vessels operated by the Marine Services Branch of the Ministry of Transport. They are the CCGS Vancouver and the CCGS Quadra. Each ship remains on station for a period of six weeks, and is then relieved by the alternate ship, thus maintaining a continuous watch.

Bathythermograph observations have been made at Station P since July 1952. A program of more extensive oceanographic observations commenced in August 1956. This was extended in April 1959, by the addition of a series of oceanographic stations along the route to and from Station P and Swiftsure Bank. These stations are known as Line P Stations. The number of stations on Line P has been increased twice and now consists of twelve stations (Fig. 1). Bathythermograph observations and surface salinity sample collections, in addition to being made on Line P oceanographic stations, are also known as Line P BT stations. Data observed prior to 1968 have been indexed by Collins et al (1969).

The present record includes hydrographic, continuously sampled STD and surface salinity and temperature data collected from the CCGS Quadra during the period 16 June to 2 August 1978.

All physical oceanographic data have been stored by the Marine Environmental Data Services Branch (MEDS), Department of Fisheries and Oceans, 240 Sparks Street, 7th Floor West, Ottawa, Ontario, Canada, K1A 0E6. Requests for these data should be directed to MEDS.

Biological and productivity data are published in the Manuscript Report series of the Department of Fisheries and Oceans (DFO), Pacific Biological Station, Nanaimo, British Columbia, Canada. Requests for these data should be directed to DFO.

Marine geochemical data are for the Ocean Chemistry Division, Department of Fisheries and Oceans, Institute of Ocean Sciences, P.O. Box 6000, Sidney, B.C., Canada, V8L 4B2.

PROGRAM OF OBSERVATIONS FROM CCGS QUADRA, 16 JUNE - 2 AUGUST 1978 (P-78-5)
(MEDS Ref. No. 15-78-005)

Oceanographic observations were made by Mr. T. Juhasz of Seakem Oceanography Ltd., Sidney, B.C.
En Route to Station P

All full Line P Stations were occupied and an STD profile made to near bottom or 1500 metres. BT's were completed at all full and half stations. Weather and sea conditions proved favourable for the entire Line P outbound.

Hydrocasts were made at Stations 6 and 10 to 1500 metres.

Samples for nitrates, nutrients, alkalinity and total CO₂ were collected at all whole stations from the seawater loop. Loop salinities² were collected at all whole and half stations. A bucket salinity sample was collected at Stations 1 and 5. Surface bucket temperatures were taken at all whole stations.

Surface tarball tows were completed at all even-numbered stations.

The thermosalinograph, surface temperature recorder, PCO₂ system and EDO sounder were run continuously.

On Station P

The oceanographic program was carried out as follows:

Physical Oceanography

- 1) Profiles for salinity, temperature and oxygen were obtained from 2 hydrocasts to 4200 metres and 4 hydrocasts to 1500 metres. These major casts were accompanied by a 1500 metre STD.
- 2) An STD was taken daily to 300 metres and twice weekly to 1500 metres.
- 3) BT's were taken every 3 hours to coincide with meteorological observations and encoded and transmitted according to the IGOSS format. XBT's were taken on days of rough weather.
- 4) Surface ocean bucket temperature and a seawater loop salinity sample were taken daily at 0000 hrs GMT.
- 5) The surface temperature recorder and the thermosalinograph were run daily and marked at 1700 hrs GMT.
- 6) Fifteen extra STD profiles were obtained to 300 metres from the triangle grids set up by Cruise 15-77-006 as part of the MILE Program.

Marine Geochemistry:

- 1) two O_2 profiles to 4200 metres and four O_2 profiles to 1500 metres.
- 2) one alkalinity profile to 4000 metres.
- 3) two nutrient profiles to 500 metres and a set of nutrient samples from the seawater loop at 0000 hrs GMT every third day on station.
- 4) one tritium profile to 500 metres accompanied by a surface bucket sample and a rainwater sample taken on the first possible occasion.
- 5) three seawater C-14 samples were taken from the seawater loop. These loop samples were accompanied by duplicate 5 litre air C-13 samples. In addition a 500 metre seawater C-14 profile was completed using the Hydrobios sampler. Both the loop samples and the 500 metre samples were also accompanied by a seawater C-13 and a total CO_2 sample as well as salinity and temperature observations.
- 6) twenty-four 2 litre and six 5 litre air CO_2 samples were taken for the Ocean Chemistry Division, I.O.S. and an additional sixteen 2 litre samples were taken for Scripps Institution of Oceanography.
- 7) a hydrocarbon sample was taken during the first week on station and the last week on station.
- 8) six tarball tows were completed on station.
- 9) two 75 metre profiles for chlorophyll a, as well as a weekly loop sample. Chlorophyll a samples were taken in triplicates of 250ml of filtered seawater.
- 10) ten samples of rainwater for Pb-210.
- 11) a weekly surface cast for particulate organic carbon (P.O.C.) and two profiles to 1500 metres at ten depths each for P.O.C. were completed, totalling 24 samples each of 5 litres of filtered seawater.
- 12) two 3000 metre casts for alkalinity standard seawater were taken.
- 13) the PCO_2 system was operated continuously. In conjunction with the PCO_2 programme twelve carboys of seawater were taken from the seawater loop.

Biological Oceanography

- 1) daily 150 metre vertical plankton hauls, using the SCOR net, for a total of 41 samples.
- 2) Six Secchi disc readings taken at local noon.
- 3) Six nitrate samples from the seawater loop, one weekly.

En Route from Station P

Line P inbound was modified to make up time CCGS Quadra lost while tending the NOAA buoy at Station Centre awaiting relief by CCGS Vancouver. The extent of the modification was:

- 1) the first Line P 1500 metre hydrocast was completed at Station P while waiting for the Vancouver.
- 2) the second Line P 1500 metre hydrocast was completed at Station 7 in a single cast using all available bottles. This resulted in the omission of 4 depths.
- 3) tarball tows were cancelled.
- 4) BT's at half stations were replaced by XBT's.

The Line P Stations 1 to 12 were occupied and an STD profile was made to near bottom or 1500 metres. BT's were taken at all full stations.

The surface temperature recorder and thermosalinograph were run continuously. The PCO₂ system was run continuously from Station P to Station 5½.

Samples for nutrients, nitrates, alkalinity and total CO₂ were collected from the seawater loop at all whole stations. Loop salinity samples were collected at all whole and half stations. Bucket salinity samples were collected at Stations 5 to 1. Surface bucket temperatures were taken at Stations 12 to 1.

Observations for Other Agencies

- 1) Marine mammal observations were made by the ship's officers for Mr. I. McAskie, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, British Columbia, Canada.
- 2) Bird observations were made by the ship's officers for Dr. M. Myres, University of Alberta, Calgary, Alberta, Canada and Mr. J. Guiguet, Curator of Birds and Mammals, Provincial Museum, Department of Provincial Secretary and Travel Industry, Victoria, British Columbia, Canada.
- 3) Air CO₂ samples were taken weekly in duplicate for Scripps Institution of Oceanography, La Jolla, California, U.S.A.

OBSERVATIONAL PROCEDURES

Observations for salinity, oxygen and temperature from all hydrographic casts, including the surface, were obtained with Niskin water sample bottles equipped with either Richter and Wiese and/or Yoshino Keiki Co. reversing thermometers. Two protected thermometers were used on all bottles and one unprotected thermometer was used on each bottle at depths of 300 metres or greater. The accuracy of protected reversing thermometers is believed to be $\pm 0.02^{\circ}\text{C}$.

The daily surface water temperatures were measured from a bucket sample using a deck thermometer of $\pm 0.1^{\circ}\text{C}$. accuracy. The daily surface salinity samples were obtained from the seawater loop. When the seawater loop was not operational these samples were obtained with a bucket, and are indicated with a 'b' in this data record.

Salinity determinations were made aboard ship with either an Autolab Model 601 Mark III inductive salinometer or a Hytech Model 6220 lab salinometer. Accuracy using duplicate determinations is estimated to be ± 0.003 ‰.

Depth determinations were made using the "depth difference" method described in the U.S.N. Hydrographic Office Publication No. 607 (1955). Depth estimates have an approximate accuracy of ± 5 metres for depths less than 1000 metres, and $\pm 0.5\%$ of depth for depths greater than 1000 metres.

The dissolved oxygen analyses were done in shipboard laboratory by a modified Winkler method (Carpenter, 1955).

Line P engine intake continuous temperature on both ships was recorded by a Honeywell Elektronik 15 Recorder. The temperature probe is at a depth of approximately 3 metres below the sea surface and the instrument accuracy is believed to be $\pm 0.1^{\circ}\text{C}$.

Each ship is equipped with a Plessey Model 6600-T thermosalinograph which is used, on Line P, for continuous recording of surface temperatures and salinities from the ship's seawater loop. The temperature probe is mounted at the seawater loop intake (approximately 3 metres below the surface) and the salinity probe and recorder are situated in the dry lab. The accuracy of this instrument is believed to be $\pm 0.1^{\circ}\text{C}$ for temperature and ± 0.1 ‰ for salinity.

STD profiles were taken with a Plessey Model 9006 STD system.

COMPUTATIONS

All hydrographic data were processed with the aid of a UNIVAC 1100 computer. Reversing thermometer temperature corrections, thermometric depth calculations and accepted depth from the "depth difference" method were computed. Extraneous thermometric depths caused by thermometer malfunctions were automatically edited and replaced. A Calcomp 565 Offline Plotter was used to plot temperature-salinity and temperature-oxygen diagrams, as well as plots of temperature, salinity and dissolved oxygen vs \log_{10} depth. These plots were used to check the data for errors.

Missing hydrographic data were obtained using a weighted parabolas interpolation method (Reiniger and Ross, 1968). These data are indicated with an asterisk in this data record.

Data values which we suspect but which we have included in this data record are indicated with a plus. These data have been removed from punch card and magnetic tape records.

Analog records from the salinity-temperature-pressure instrument have been machine digitized, then replotted using the Calcomp plotter.

Digitization was continued until original and computer plotted traces were coincident. Temperature and salinity values were listed at standard pressure; integrals (depths, geopotential anomaly, and potential energy anomaly) were computed from the entire array of digitized data.

The headings for the data listings are explained as follows:

| | |
|-------------|---|
| PRESS | is pressure (decibars) |
| TEMP | is temperature (degree Celsius) |
| SAL | is salinity (parts per thousand) |
| DEPTH | is reported in metres |
| SIGMA-T | is specific gravity anomaly |
| SVA | is specific volume anomaly |
| THETA | is potential temperature (degrees Celsius) |
| SVA (THETA) | is potential specific volume anomaly |
| DELTA D | is geopotential anomaly (J/kg) |
| POT EN | is potential energy in units of 10^8 ergs/cm ² |
| OXY | is the concentration of dissolved oxygen expressed in millilitres per litre |
| SOUND | is the velocity of sound in m/sec |

Data were processed for publication by Interact Computing Services Ltd.

REFERENCES

- Carpenter, J.H., 1965. The Chesapeake Bay Institute technique for the Winkler dissolved oxygen method. *Limnol. and Oceanogr.* 10, 141-143.
- Collins, C.A., R.L. Tripe, D.A. Healey and J. Joergensen, 1969. The time distribution of serial oceanographic data from the Ocean Station P programme. *Fish. Res. Bd. Can. Tech. Rept. No.* 106.
- MacNeill, M., 1977. A study of anomalous salinity and oxygen values in the deep water at Ocean Station P from 1960-1976 (unpublished manuscript). *Pacific Marine Science Report* 77-9.
- Reiniger, R.F. and C.K. Ross, 1968. A method of interpolation with application to oceanographic data. *Deep Sea Res.* 15, 185-193.
- U.S.N. Hydrographic Office, 1955. Instruction Manual for oceanographic observations. *Publ. No.* 607.

LOG OF HYDROGRAPHIC AND STD OBSERVATIONS

| Consec. # | Station | Date (Z) | Time (Z) | STD (m) | Hydrocast (m) | Comments |
|-----------|---------|----------|----------|---------|---------------|--|
| 001 | 1 | 16/06/78 | 2355 | 90 | | |
| 002 | 2 | 17/06/78 | 0135 | 80 | | |
| 004 | 4 | 17/06/78 | 0715 | 300 | | |
| 005 | 5 | 17/06/78 | 1115 | 1480 | | |
| 006 | 6 | 17/06/78 | 1750 | 1480 | | |
| 007 | 6 | 17/06/78 | 2010 | | 1490 | T,S |
| 008 | 7 | 18/06/78 | 0230 | 1480 | | |
| 009 | 8 | 18/06/78 | 0900 | 1480 | | |
| 010 | 9 | 18/06/78 | 1540 | 1480 | | |
| 011 | 10 | 18/06/78 | 2210 | 1480 | | |
| 012 | 10 | 19/06/78 | 0020 | | 1460 | T,S |
| 013 | 11 | 19/06/78 | 0620 | 1480 | | |
| 014 | 12 | 19/06/78 | 1350 | 1480 | | |
| 015 | P | 20/06/78 | 1710 | 1480 | | |
| 016 | P | 20/06/78 | 1825 | | 4200 | T,S,O ₂ |
| 017 | P | 21/06/78 | 1700 | 300 | | |
| 018 | P | 22/06/78 | 1700 | 300 | | |
| 019 | P | 22/06/78 | 1750 | | 500 | T,S,Tritium Nutrient |
| 020 | P | 22/06/78 | 1810 | | 0 | T,S,P.O.C. |
| 021 | P | 23/06/78 | 1700 | 1480 | | |
| 022 | P | 23/06/78 | 1745 | | 75 | Chlor-a |
| 023 | P | 24/06/78 | 1700 | 300 | | |
| 024 | E3 | 24/06/78 | 1820 | 300 | | |
| 025 | E4 | 24/06/78 | 1935 | 300 | | |
| 026 | C1 | 24/06/78 | 2100 | 300 | | |
| 027 | W4 | 24/06/78 | 2220 | 300 | | |
| 028 | W3 | 25/06/78 | 0030 | 300 | | |
| 029 | P | 25/06/78 | 1700 | 300 | | |
| 030 | P | 25/06/78 | 1700 | | 290 | T,S (top/bot STD check) |
| 031 | P | 26/06/78 | 1700 | 1480 | | |
| 032 | P | 26/06/78 | 1940 | | 1500 | T,S,O ₂ |
| 033 | P | 27/06/78 | 1700 | 300 | | |
| 034 | P | 28/06/78 | 1700 | 300 | | |
| 035 | P | 28/06/78 | 1730 | | 1500 | T,S,P.O.C. |
| 043 | P | 29/06/78 | 1700 | 1480 | | |
| 044 | P | 29/06/78 | 1830 | | 100 | T,S,SWC-14 SWC-13,Tot CO ₂ |
| 045 | P | 30/06/78 | 1700 | 300 | | |
| 046 | P | 30/06/78 | 1745 | | 500 | T,S,SWC-14 SWC-13,Tot CO ₂ |
| 047 | P | 01/07/78 | 1700 | 300 | | |
| 048 | P | 01/07/78 | 1745 | | 400 | T,S,SWC-14 SWC-13,Tot CO ₂ |
| 049 | P | 02/07/78 | 1700 | 300 | | |
| 050 | P | 02/07/78 | 1745 | | 300 | T,S,SWC-14 SWC-13,Tot CO ₂ |
| 051 | P | 03/07/78 | 1900 | 1480 | | |
| 052 | P | 03/07/78 | 2010 | | 4230 | T,S,O ₂ |

LOG OF HYDROGRAPHIC AND STD OBSERVATIONS (continued)

| Consec # | Station | Date (Z) | Time (Z) | STD (m) | Hydrocast (m) | Comments |
|----------|---------|----------|----------|---------|---------------|--|
| 053 | P | 04/07/78 | 2015 | 1480 | | |
| 054 | P | 05/07/78 | 1700 | 300 | | |
| 055 | P | 05/07/78 | 1730 | | 0 | T,S,P.O.C. |
| 056 | P | 06/07/78 | 1700 | 300 | | |
| 057 | P | 06/07/78 | 1800 | | 200 | T,S,SWC-14 SWC-13,Tot CO ₂ |
| 058 | P | 07/07/78 | 1700 | 300 | | |
| 059 | P | 07/07/78 | 1750 | | 500 | T,S,Nutrient |
| 060 | P | 08/07/78 | 1700 | 300 | | |
| 061 | E3 | 08/07/78 | 1825 | 300 | | |
| 062 | E4 | 08/07/78 | 1935 | 300 | | |
| 063 | C1 | 08/07/78 | 2045 | 300 | | |
| 064 | W4 | 08/07/78 | 2200 | 300 | | |
| 065 | W3 | 08/07/78 | 2310 | 300 | | |
| 066 | P | 09/07/78 | 1700 | 300 | | |
| 067 | P | 10/07/78 | 1700 | 1480 | | |
| 068 | P | 10/07/78 | 1940 | | 1510 | T,S,O ₂ |
| 069 | P | 11/07/78 | 1700 | 300 | | |
| 070 | P | 11/07/78 | 1720 | | 75 | Chlor-a |
| 071 | P | 12/07/78 | 1700 | 300 | | |
| 072 | P | 12/07/78 | 1730 | | 1490 | T,S,P.O.C. |
| 080 | P | 13/07/78 | 1700 | 300 | | |
| 081 | P | 14/07/78 | 1700 | 1480 | | |
| 082 | P | 14/07/78 | 1700 | | 1500 | T,S (top/bot STD check) |
| 083 | P | 15/07/78 | 1700 | 300 | | |
| 084 | P | 16/07/78 | 1700 | 300 | | |
| 085 | P | 17/07/78 | 1700 | 1480 | | |
| 086 | P | 17/07/78 | 1800 | | 1500 | T,S,O ₂ |
| 087 | P | 18/07/78 | 1700 | 300 | | |
| 088 | P | 18/07/78 | 1820 | | 0 | T,S,P.O.C. |
| 089 | P | 19/07/78 | 1700 | 300 | | |
| 090 | P | 19/07/78 | 1720 | | 3000 | T,S,Alk std. |
| 091 | P | 19/07/78 | 1850 | | 3000 | T,S,Alk std. |
| 092 | P | 20/07/78 | 1700 | 300 | | |
| 093 | P | 21/07/78 | 1700 | 1480 | | |
| 094 | P | 22/07/78 | 1700 | 300 | | |
| 095 | P | 23/07/78 | 1700 | 300 | | |
| 096 | E3 | 23/07/78 | 1825 | 300 | | |
| 097 | E4 | 23/07/78 | 1945 | 300 | | |
| 098 | C1 | 23/07/78 | 2100 | 300 | | |
| 099 | W4 | 23/07/78 | 2230 | 300 | | |
| 100 | W3 | 24/07/78 | 0030 | 300 | | |
| 101 | P | 24/07/78 | 1700 | 1480 | | |
| 102 | P | 24/07/78 | 1825 | | 1485 | T,S,O ₂ |
| 103 | P | 24/07/78 | 1955 | | 0 | T,S,P.O.C. |
| 104 | P | 25/07/78 | 1700 | 300 | | |
| 105 | P | 26/07/78 | 1700 | 300 | | |
| 106 | P | 27/07/78 | 1700 | 1480 | | |
| 107 | P | 28/07/78 | 1700 | 300 | | |

LOG OF HYDROGRAPHIC AND STD OBSERVATIONS (continued)

| Consec # | Station | Date (Z) | Time (Z) | STD (m) | Hydrocast (m) | Comments |
|----------|---------|----------|----------|---------|---------------|----------|
| 108 | P | 29/07/78 | 1700 | 300 | 1500 | T,S |
| 109 | P | 30/07/78 | 1800 | 1480 | | |
| 110 | P | 30/07/78 | 1950 | | | |
| 111 | 12 | 31/07/78 | 0900 | 1480 | | |
| 112 | 11 | 31/07/78 | 1500 | 1480 | | |
| 113 | 10 | 31/07/78 | 2100 | 1480 | 1470 | T,S |
| 114 | 9 | 01/08/78 | 0255 | 1480 | | |
| 115 | 8 | 01/08/78 | 0900 | 1480 | | |
| 116 | 7 | 01/08/78 | 1500 | 1480 | | |
| 117 | 7 | 01/08/78 | 1625 | | | |
| 118 | 6 | 01/08/78 | 2225 | 1480 | | |
| 119 | 5 | 02/08/78 | 0510 | 1480 | | |
| 120 | 4 | 02/08/78 | 0850 | 1480 | | |
| 121 | 3 | 02/08/78 | 1300 | 1190 | | |
| 122 | 2 | 02/08/78 | 1540 | 80 | | |
| 123 | 1 | 02/08/78 | 1735 | 90 | | |

Note: P.O.C. = particulate organic carbon

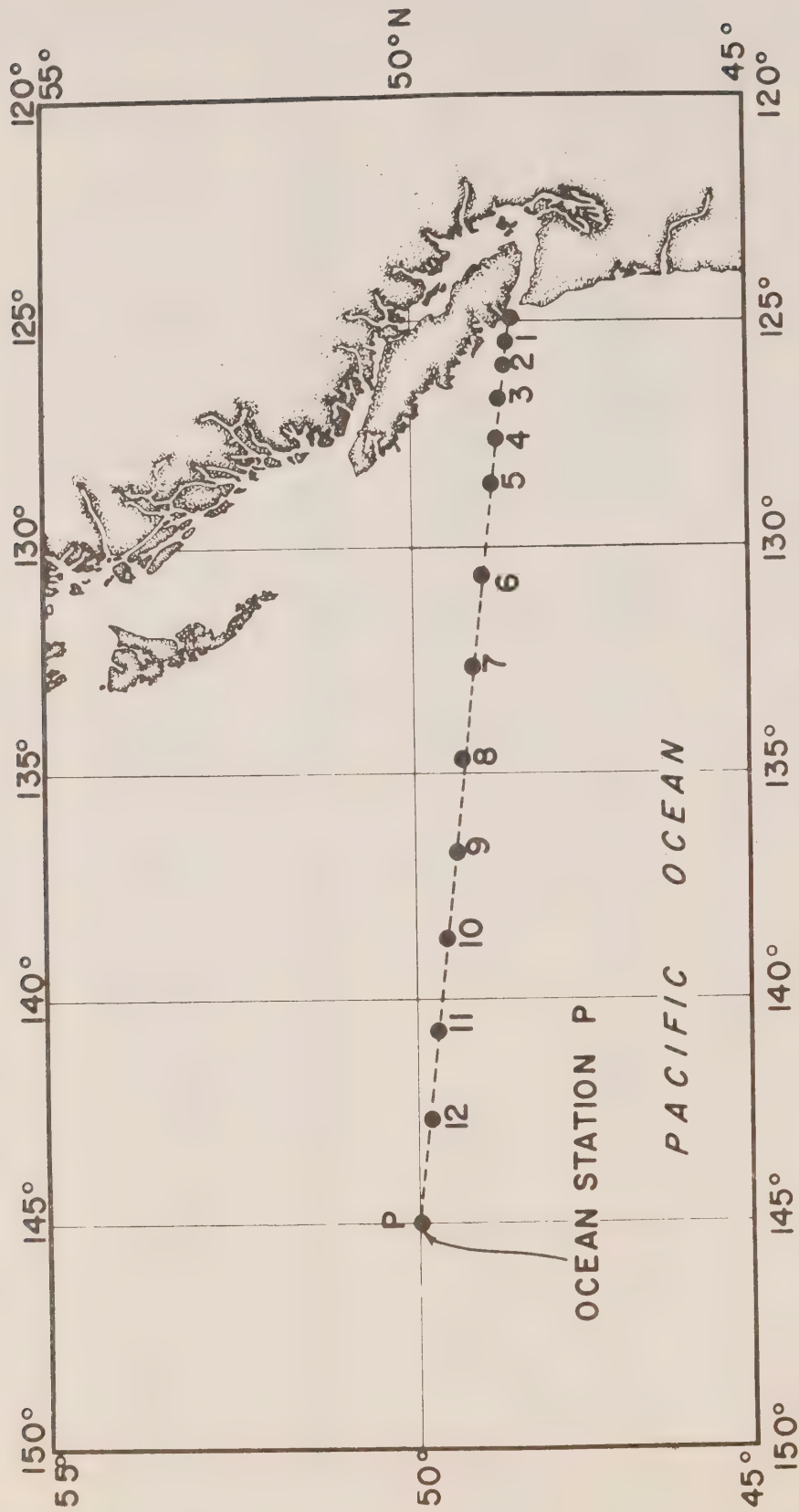


Fig. 1 Chart showing Line P station positions.

Oceanographic Data Obtained on Cruise P-78-5

(MEDS Reference No. 15-78-005)

Results of Hydrographic Observations
(P-78-5)

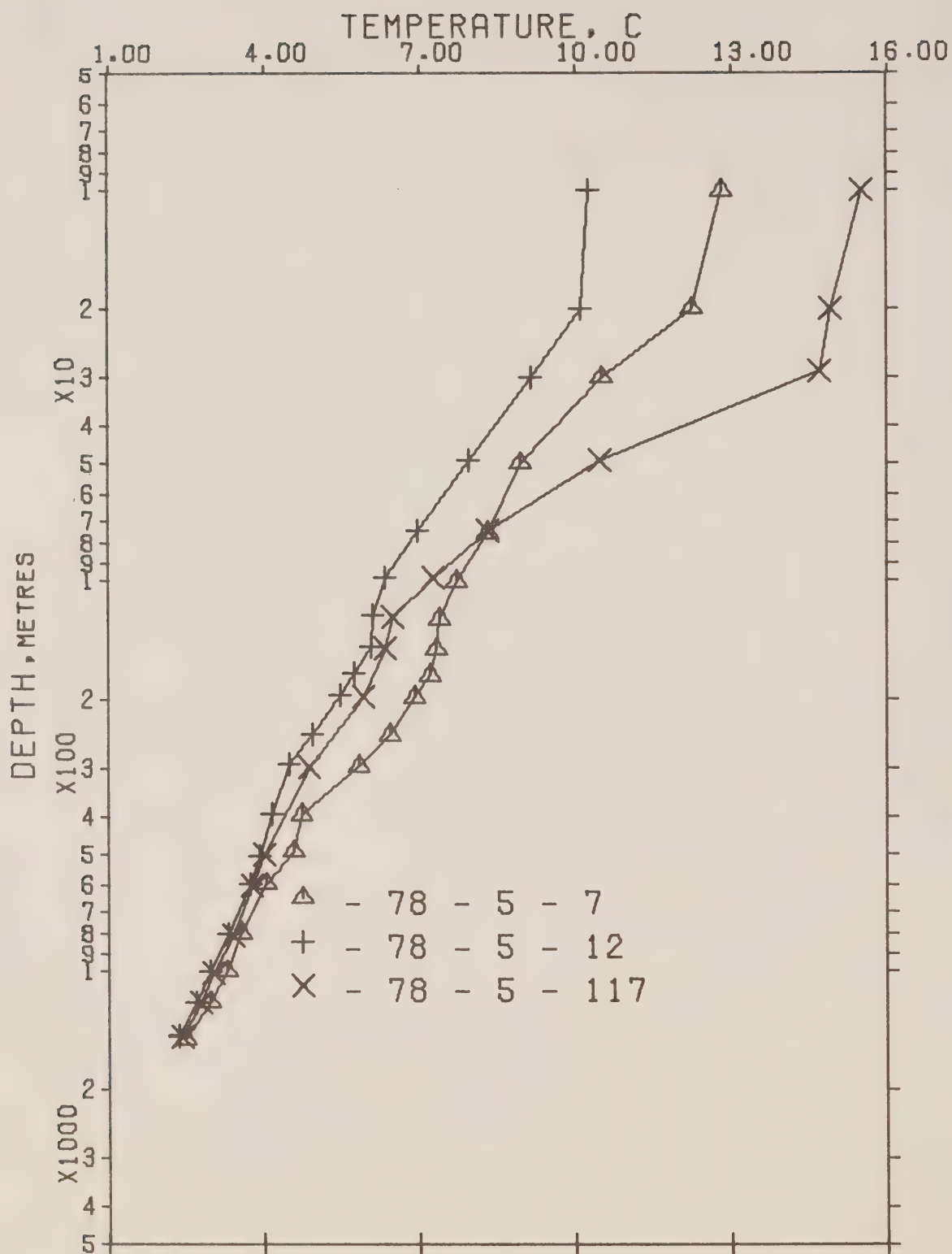


Figure 2. Composite plot of temperature vs \log_{10} depth for Line P Stations.

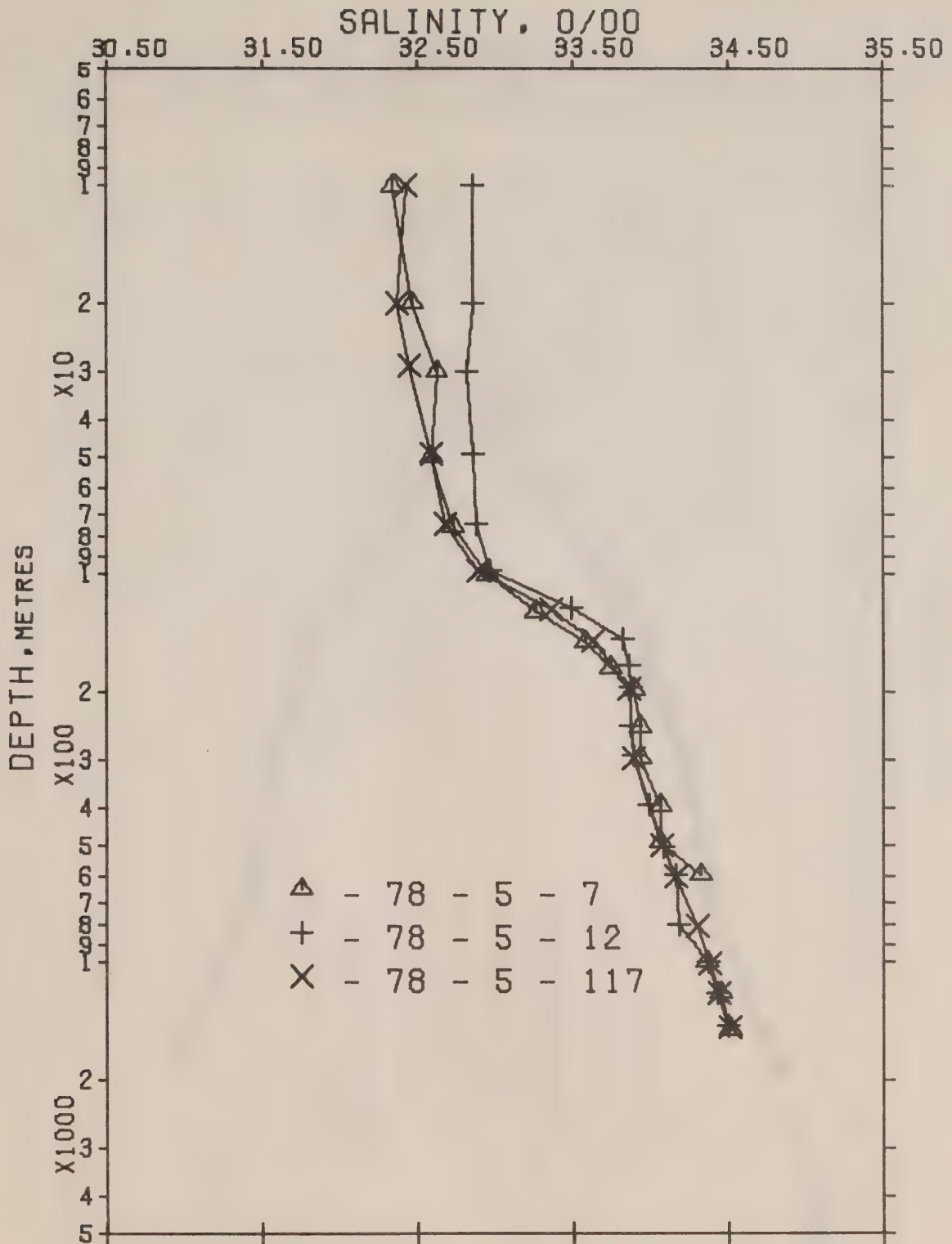


Figure 3. Composite plot of salinity vs \log_{10} depth for Line P Stations.

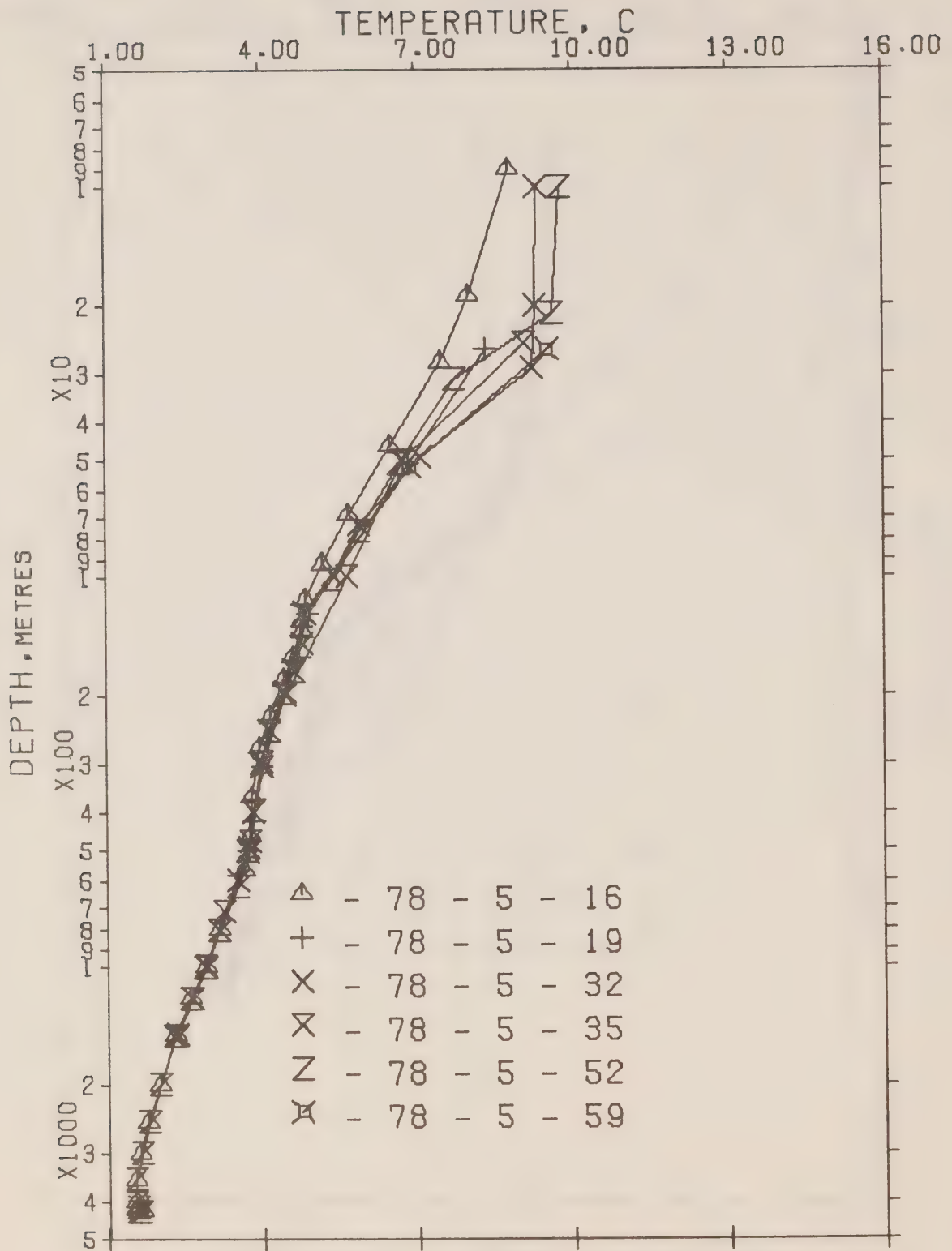


Figure 4(a). Composite plot of temperature vs \log_{10} depth for Station P.

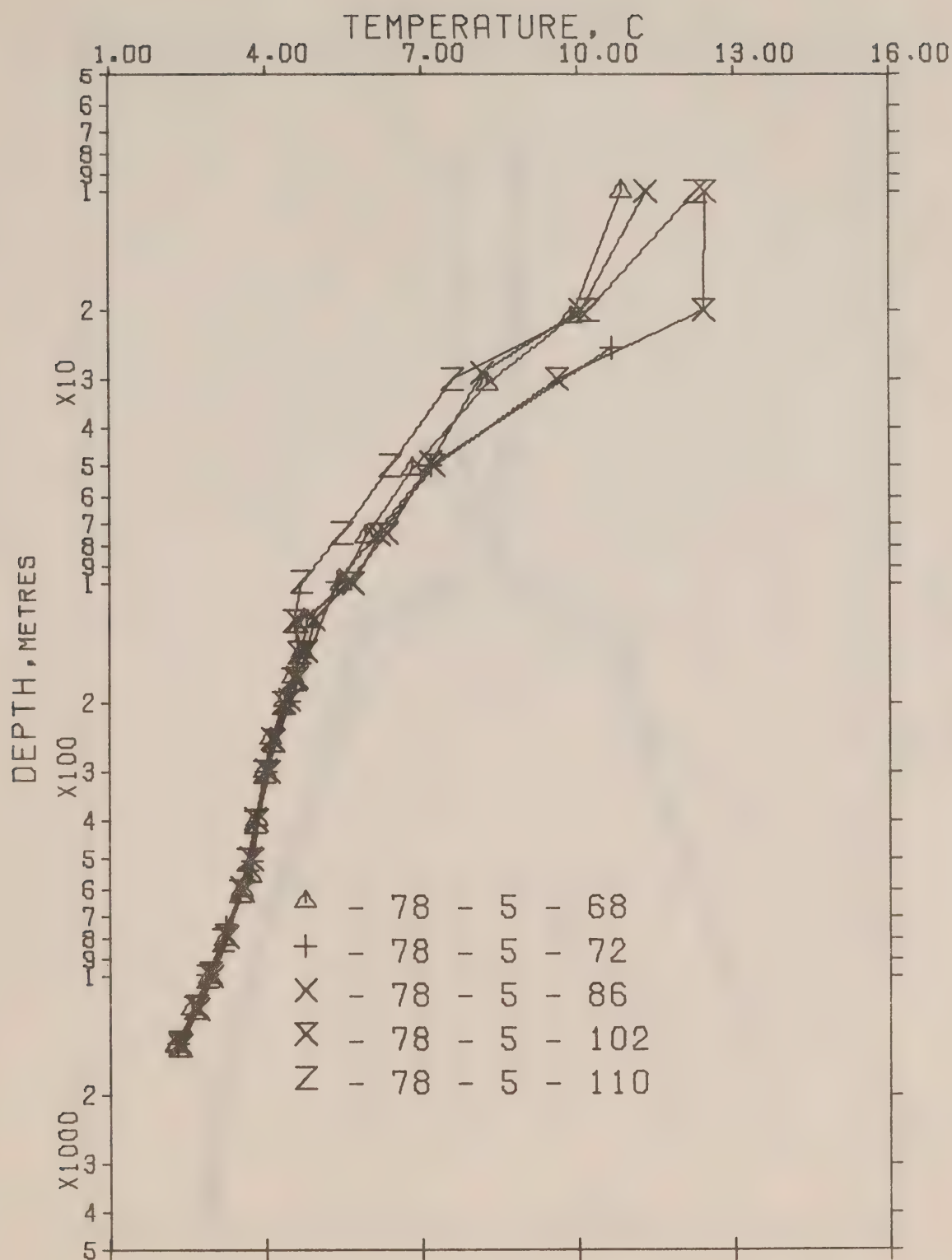


Figure 4(b). Composite plot of temperature vs \log_{10} depth for Station P.

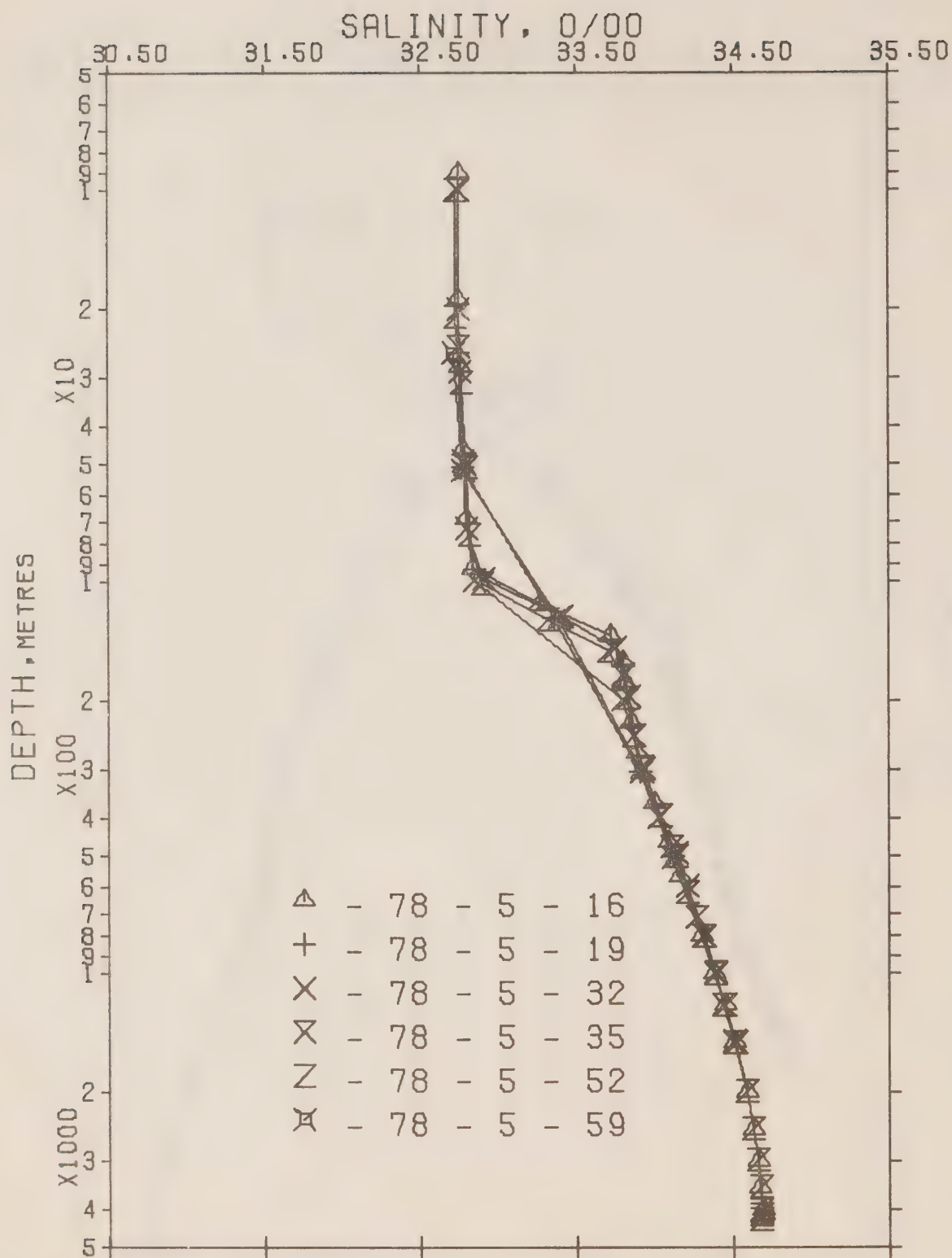


Figure 5(a). Composite plot of salinity vs \log_{10} depth for Station P.

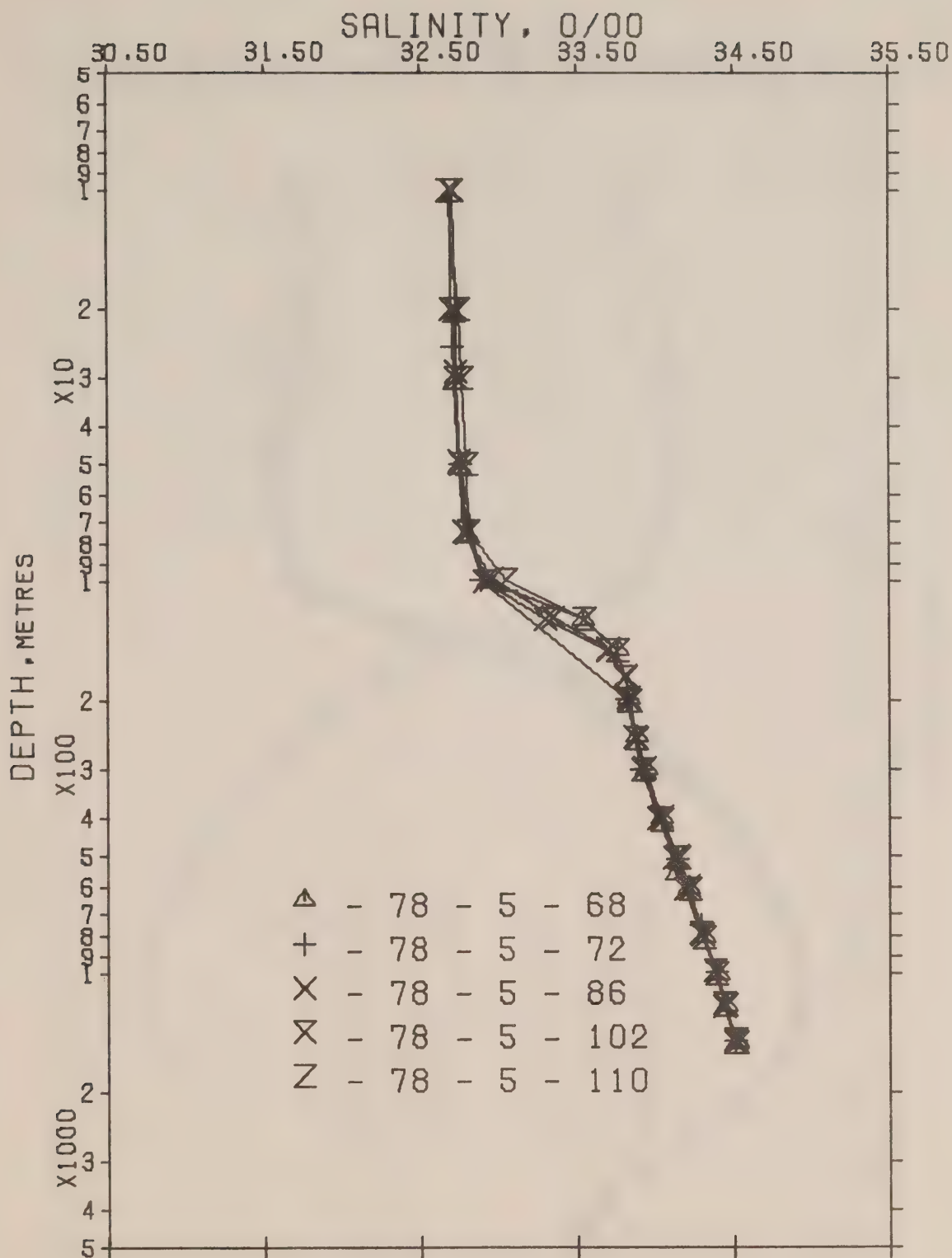


Figure 5(b). Composite plot of salinity vs \log_{10} depth for Station P.

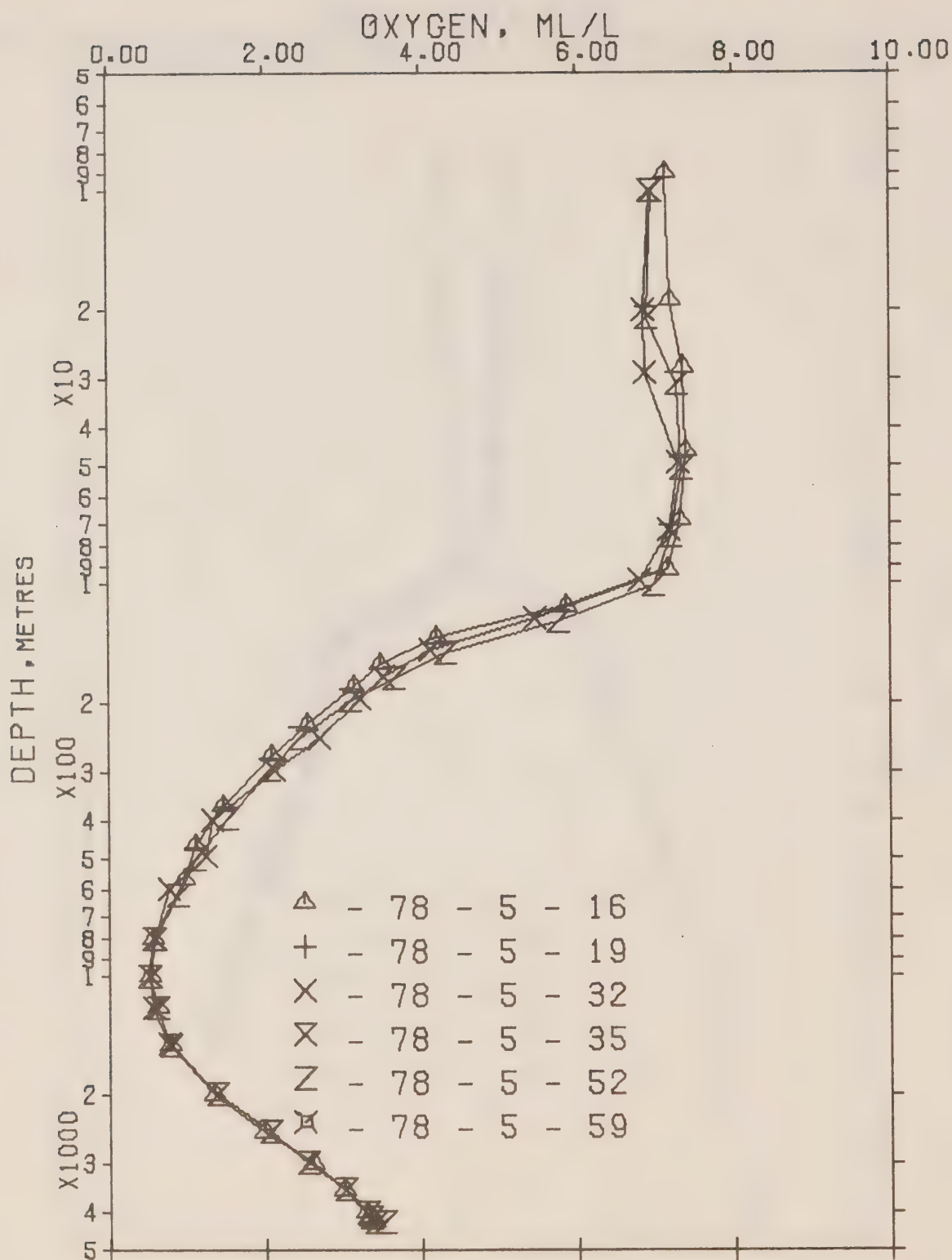


Figure 6(a). Composite plot of oxygen vs \log_{10} depth for Station P.

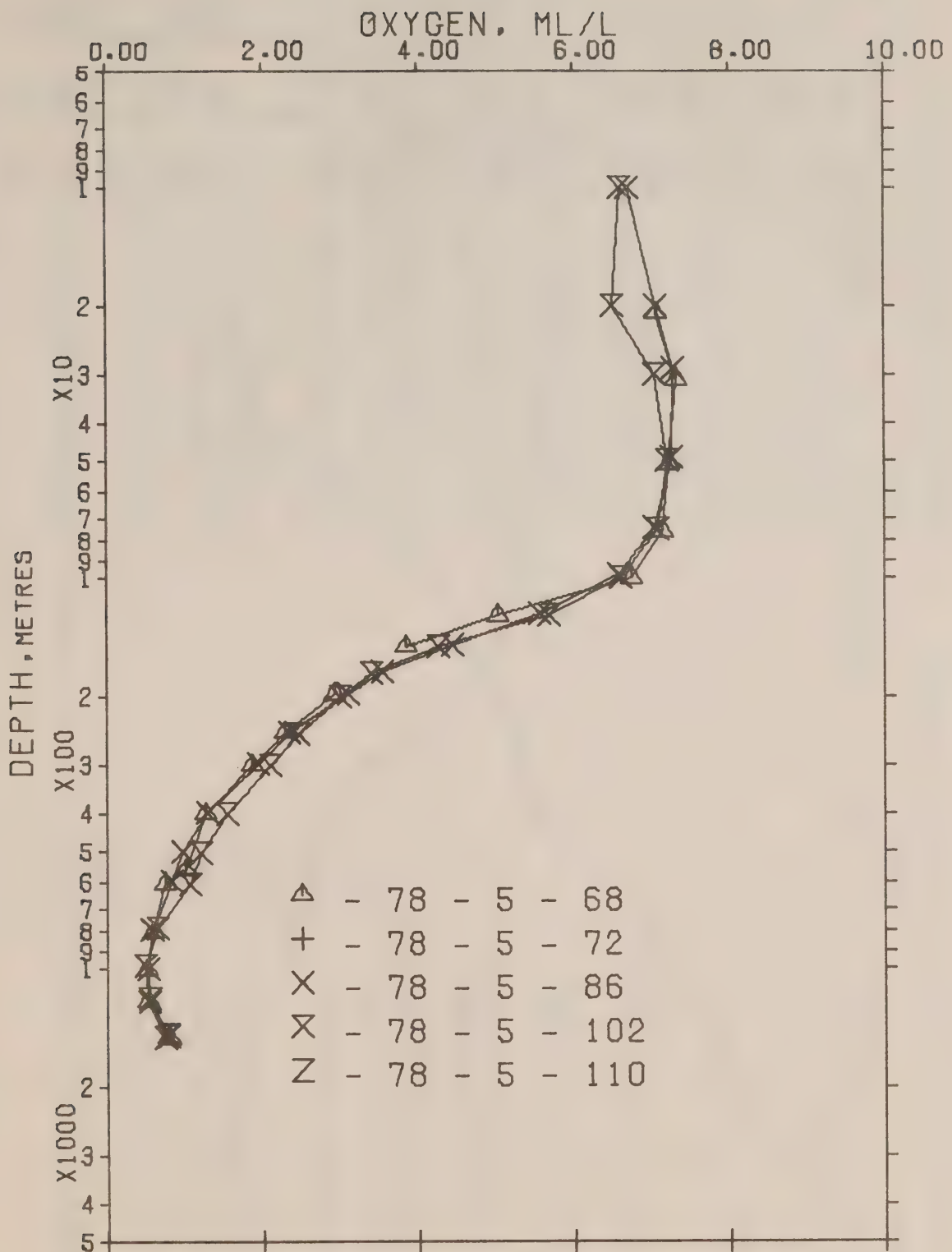
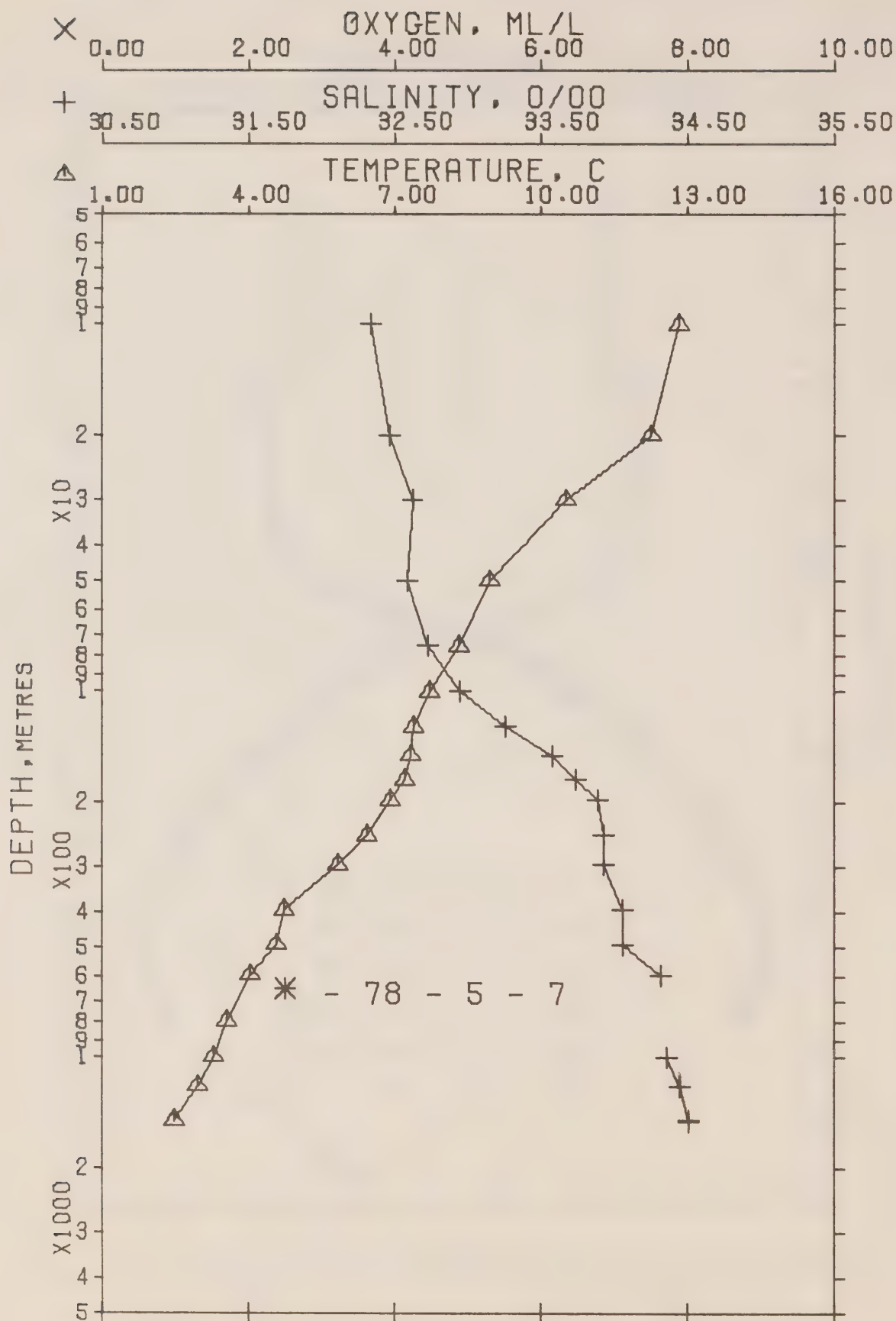


Figure 6(b). Composite plot of oxygen vs \log_{10} depth for Station P.



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 7

DATE 17/ 6/78

GMT 20.2

POSITION 49- 2.0 N, 130-40.0 W

STATION 6

HYDROGRAPHIC CAST DATA

OBSERVED DATA

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|-------|--------|-------|------------|-------|-------|----------------|------------|------------|-----|-------|
| 0 | 12.85 | 32.349 | 0 | 24.394 | 354.4 | 12.85 | 354.4 | .00 | .00 | | 1497. |
| 10 | 12.82 | 32.343 | 10 | 24.395 | 354.5 | 12.82 | 354.2 | .36 | .02 | | 1497. |
| 20 | 12.25 | 32.472 | 20 | 24.604 | 334.8 | 12.25 | 334.3 | .70 | .07 | | 1495. |
| 30 | 10.51 | 32.625 | 30 | 25.036 | 293.8 | 10.51 | 293.1 | 1.02 | .15 | | 1490. |
| 50 | 8.95 | 32.592 | 50 | 25.266 | 272.2 | 8.94 | 271.3 | 1.58 | .38 | | 1484. |
| 75 | 8.33 | 32.729 | 75 | 25.467 | 253.4 | 8.32 | 252.1 | 2.24 | .81 | | 1482. |
| 101 | 7.73 | 32.954 | 100 | 25.731 | 228.7 | 7.72 | 227.0 | 2.85 | 1.35 | | 1481. |
| 126 | 7.39 | 33.265 | 125 | 26.023 | 201.3 | 7.38 | 199.3 | 3.39 | 1.97 | | 1480. |
| 150 | 7.34 | 33.576 | 149 | 26.274 | 177.9 | 7.33 | 175.4 | 3.85 | 2.62 | | 1481. |
| 175 | 7.21 | 33.738 | 174 | 26.419 | 164.5 | 7.19 | 161.6 | 4.28 | 3.33 | | 1481. |
| 199 | 6.92 | 33.890 | 198 | 26.578 | 149.6 | 6.90 | 146.5 | 4.66 | 4.05 | | 1481. |
| 249 | 6.43 | 33.930 | 247 | 26.675 | 140.9 | 6.41 | 137.2 | 5.37 | 5.08 | | 1479. |
| 298 | 5.84 | 33.932 | 296 | 26.752 | 133.9 | 5.81 | 129.9 | 6.05 | 7.58 | | 1478. |
| 397 | 4.72 | 34.057 | 394 | 26.982 | 112.4 | 4.69 | 108.0 | 7.26 | 11.82 | | 1475. |
| 494 | 4.57 | 34.059 | 490 | 27.000 | 111.5 | 4.53 | 106.2 | 8.34 | 16.75 | | 1476. |
| 599 | 4.04 | 34.325 | 594 | 27.268 | 86.7 | 4.00 | 80.9 | 9.38 | 22.51 | | 1476. |
| 802 | 3.56 | 34.347 | 795 | 27.334 | 81.3 | 3.50 | 74.5 | 11.08 | 34.66 | | 1477. |
| 1005 | 3.28 | 34.364 | 995 | 27.374 | 78.4 | 3.21 | 70.6 | 12.70 | 49.52 | | 1479. |
| 1208 | 2.95 | 34.446 | 1196 | 27.470 | 69.9 | 2.86 | 61.4 | 14.21 | 66.53 | | 1481. |
| 1499 | 2.48 | 34.508 | 1483 | 27.561 | 61.6 | 2.38 | 52.7 | 16.07 | 92.28 | | 1484. |
| 1509 | 2.46 | 34.505 | 1493 | 27.560 | 61.7 | 2.36 | 52.8 | 16.14 | 93.24 | | 1484. |

OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 7

DATE 17/ 6/78

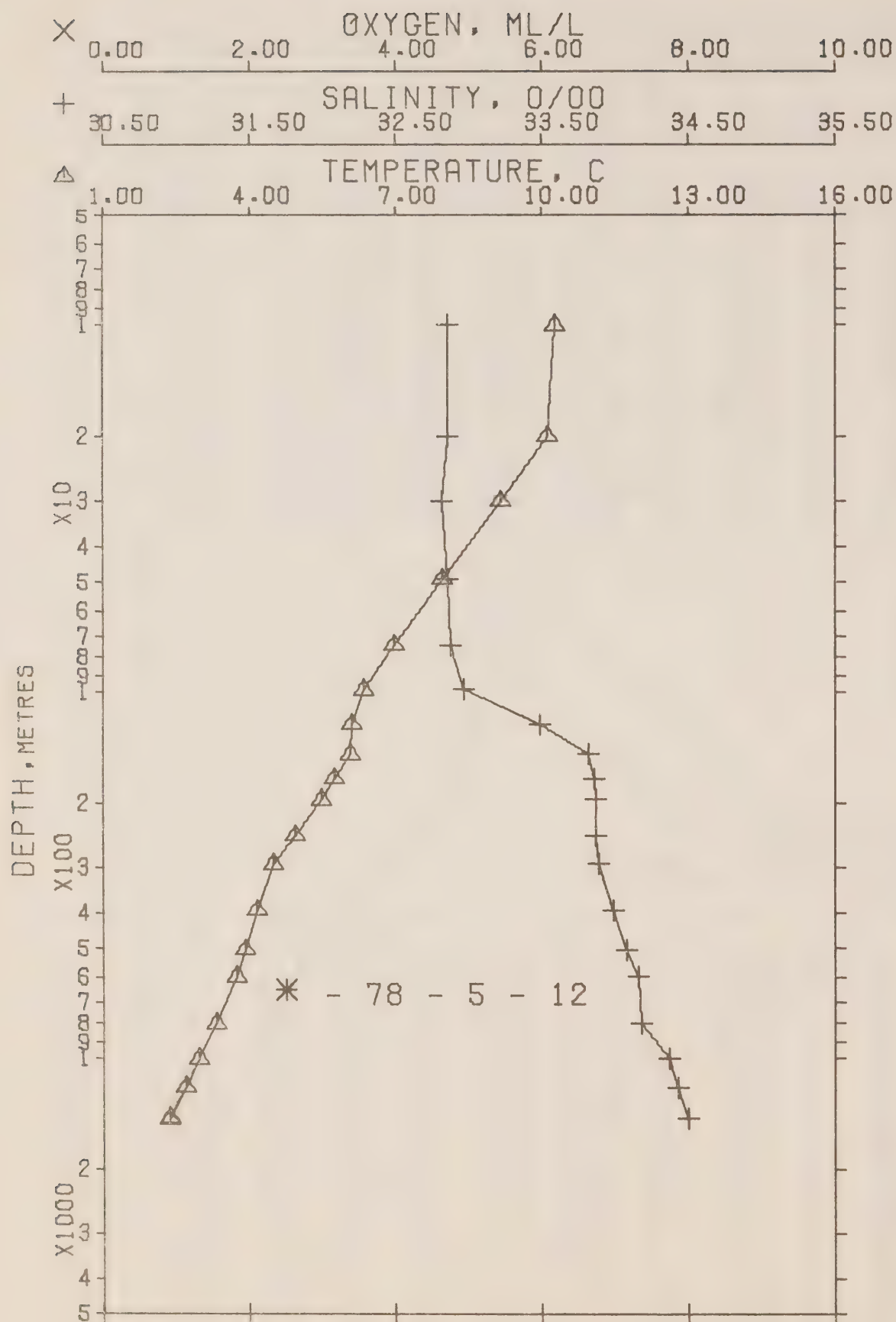
GMT 20.2

POSITION 49- 2.0 N, 130-40.0 W

STATION 6

INTERPOLATED TO STANDARD PRESSURE

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|-------|--------|-------|------------|-------|-------|----------------|------------|------------|-----|-------|
| 0 | 12.85 | 32.349 | 0 | 24.394 | 354.4 | 12.85 | 354.4 | .00 | .00 | | 1497. |
| 10 | 12.82 | 32.343 | 10 | 24.395 | 354.5 | 12.82 | 354.2 | .36 | .02 | | 1497. |
| 20 | 12.25 | 32.472 | 20 | 24.604 | 334.8 | 12.25 | 334.3 | .70 | .07 | | 1495. |
| 30 | 10.51 | 32.625 | 30 | 25.036 | 293.8 | 10.51 | 293.1 | 1.02 | .15 | | 1490. |
| 50 | 8.95 | 32.592 | 50 | 25.266 | 272.2 | 8.94 | 271.3 | 1.58 | .38 | | 1484. |
| 75 | 8.33 | 32.729 | 75 | 25.467 | 253.4 | 8.32 | 252.1 | 2.24 | .81 | | 1482. |
| 100 | 7.74 | 32.949 | 99 | 25.725 | 229.2 | 7.73 | 227.5 | 2.84 | 1.33 | | 1481. |
| 125 | 7.40 | 33.257 | 124 | 26.015 | 202.0 | 7.39 | 200.0 | 3.38 | 1.95 | | 1480. |
| 150 | 7.34 | 33.576 | 149 | 26.274 | 177.9 | 7.33 | 175.4 | 3.85 | 2.62 | | 1481. |
| 175 | 7.21 | 33.738 | 174 | 26.419 | 164.5 | 7.19 | 161.6 | 4.28 | 3.33 | | 1481. |
| 200 | 6.91 | 33.891 | 199 | 26.580 | 149.5 | 6.89 | 146.3 | 4.67 | 4.07 | | 1481. |
| 225 | 6.65 | 33.912 | 223 | 26.631 | 144.8 | 6.63 | 141.4 | 5.03 | 4.86 | | 1480. |
| 250 | 6.41 | 33.930 | 248 | 26.677 | 140.7 | 6.39 | 137.0 | 5.39 | 5.73 | | 1479. |
| 300 | 5.82 | 33.935 | 298 | 26.757 | 133.4 | 5.79 | 129.4 | 6.08 | 7.66 | | 1478. |
| 400 | 4.71 | 34.057 | 397 | 26.983 | 112.4 | 4.68 | 108.0 | 7.29 | 11.96 | | 1475. |
| 500 | 4.54 | 34.076 | 496 | 27.018 | 109.9 | 4.50 | 104.6 | 8.41 | 17.09 | | 1476. |
| 600 | 4.04 | 34.325 | 595 | 27.268 | 86.6 | 3.99 | 80.8 | 9.39 | 22.57 | | 1476. |
| 700 | 3.78 | 34.337 | 694 | 27.303 | 83.8 | 3.73 | 77.4 | 10.24 | 28.21 | | 1477. |
| 800 | 3.56 | 34.347 | 793 | 27.333 | 81.4 | 3.51 | 74.6 | 11.06 | 34.52 | | 1477. |
| 900 | 3.42 | 34.356 | 892 | 27.355 | 79.8 | 3.35 | 72.5 | 11.87 | 41.49 | | 1478. |
| 1000 | 3.29 | 34.364 | 991 | 27.373 | 78.5 | 3.21 | 70.7 | 12.66 | 49.16 | | 1479. |
| 1200 | 2.96 | 34.443 | 1188 | 27.466 | 70.2 | 2.88 | 61.7 | 14.15 | 65.83 | | 1481. |
| 1500 | 2.48 | 34.508 | 1484 | 27.561 | 61.6 | 2.37 | 52.7 | 16.08 | 92.36 | | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 12

DATE 19/ 6/78

GMT .3

POSITION 49-34.0 N, 138-40.0 W

STATION 10

HYDROGRAPHIC CAST DATA

OBSERVED DATA

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|-------|--------|-------|------------|-------|-------|----------------|------------|------------|-----|-------|
| 0 | 10.28 | 32.860 | 0 | 25.258 | 272.1 | 10.28 | 272.1 | .00 | .00 | | 1489. |
| 10 | 10.26 | 32.858 | 10 | 25.260 | 272.1 | 10.26 | 271.9 | .27 | .01 | | 1489. |
| 20 | 10.12 | 32.855 | 20 | 25.281 | 270.3 | 10.12 | 269.8 | .55 | .06 | | 1488. |
| 30 | 9.16 | 32.819 | 30 | 25.410 | 258.2 | 9.16 | 257.6 | .81 | .12 | | 1485. |
| 49 | 7.97 | 32.857 | 49 | 25.620 | 238.4 | 7.97 | 237.6 | 1.29 | .32 | | 1481. |
| 74 | 6.98 | 32.876 | 74 | 25.774 | 224.1 | 6.97 | 223.0 | 1.87 | .68 | | 1477. |
| 99 | 6.35 | 32.974 | 98 | 25.933 | 209.1 | 6.34 | 207.8 | 2.40 | 1.15 | | 1475. |
| 123 | 6.10 | 33.495 | 122 | 26.375 | 167.5 | 6.09 | 165.8 | 2.85 | 1.66 | | 1475. |
| 148 | 6.06 | 33.824 | 147 | 26.639 | 142.8 | 6.05 | 140.8 | 3.24 | 2.20 | | 1476. |
| 172 | 5.75 | 33.863 | 171 | 26.708 | 136.4 | 5.74 | 134.2 | 3.58 | 2.75 | | 1475. |
| 197 | 5.48 | 33.867 | 196 | 26.744 | 133.2 | 5.46 | 130.7 | 3.92 | 3.39 | | 1475. |
| 247 | 4.94 | 33.872 | 245 | 26.811 | 127.2 | 4.92 | 124.4 | 4.56 | 4.84 | | 1473. |
| 296 | 4.48 | 33.894 | 294 | 26.880 | 120.9 | 4.46 | 117.9 | 5.18 | 6.54 | | 1472. |
| 396 | 4.15 | 33.990 | 393 | 26.991 | 111.0 | 4.12 | 107.3 | 6.33 | 10.01 | | 1473. |
| 507 | 3.91 | 34.084 | 503 | 27.090 | 102.4 | 3.87 | 97.8 | 7.51 | 16.06 | | 1474. |
| 602 | 3.72 | 34.159 | 597 | 27.169 | 95.5 | 3.68 | 90.3 | 8.45 | 21.37 | | 1474. |
| 808 | 3.31 | 34.176 | 801 | 27.222 | 91.3 | 3.25 | 85.1 | 10.37 | 35.15 | | 1476. |
| 1011 | 2.95 | 34.366 | 1001 | 27.406 | 74.6 | 2.88 | 67.6 | 12.05 | 50.67 | | 1478. |
| 1207 | 2.69 | 34.429 | 1195 | 27.480 | 68.3 | 2.61 | 60.6 | 13.44 | 66.34 | | 1480. |
| 1471 | 2.36 | 34.497 | 1455 | 27.562 | 60.9 | 2.26 | 52.6 | 15.14 | 89.50 | | 1483. |

OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 12

DATE 19/ 6/78

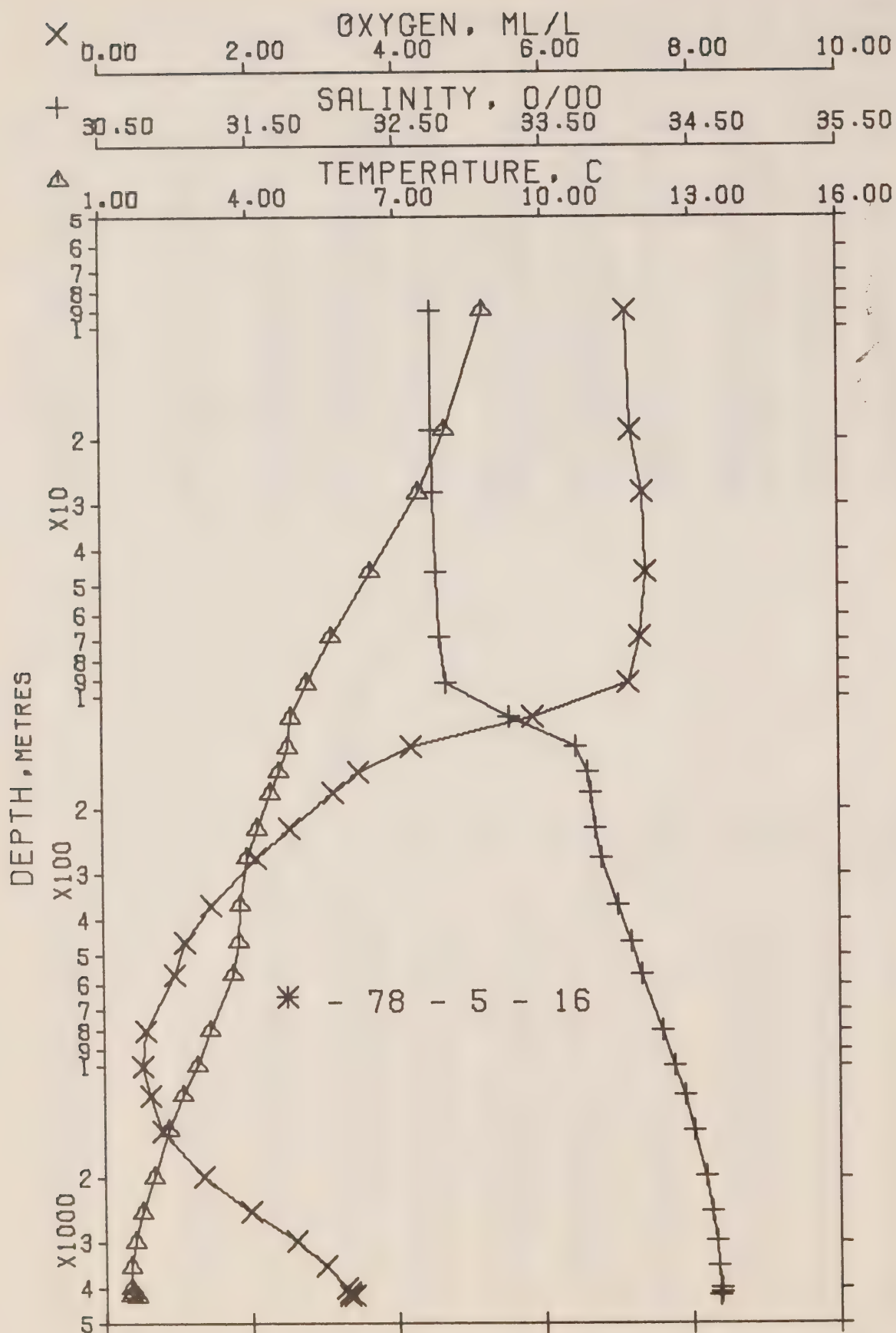
GMT .3

POSITION 49-34.0 N, 138-40.0 W

STATION 10

INTERPOLATED TO STANDARD PRESSURE

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|-------|--------|-------|------------|-------|-------|----------------|------------|------------|-----|-------|
| 0 | 10.28 | 32.860 | 0 | 25.258 | 272.1 | 10.28 | 272.1 | .00 | .00 | | 1489. |
| 10 | 10.26 | 32.858 | 10 | 25.260 | 272.1 | 10.26 | 271.9 | .27 | .01 | | 1489. |
| 20 | 10.12 | 32.855 | 20 | 25.281 | 270.3 | 10.12 | 269.8 | .55 | .06 | | 1488. |
| 30 | 9.16 | 32.819 | 30 | 25.410 | 258.2 | 9.16 | 257.6 | .81 | .12 | | 1485. |
| 50 | 7.94 | 32.858 | 50 | 25.626 | 237.9 | 7.93 | 237.1 | 1.30 | .32 | | 1481. |
| 75 | 6.96 | 32.879 | 75 | 25.778 | 223.7 | 6.96 | 222.6 | 1.88 | .69 | | 1477. |
| 100 | 6.33 | 33.007 | 99 | 25.961 | 206.5 | 6.33 | 205.2 | 2.43 | 1.18 | | 1475. |
| 125 | 6.10 | 33.526 | 124 | 26.400 | 165.2 | 6.09 | 163.5 | 2.89 | 1.71 | | 1476. |
| 150 | 6.03 | 33.827 | 149 | 26.645 | 142.2 | 6.02 | 140.2 | 3.27 | 2.24 | | 1476. |
| 175 | 5.72 | 33.863 | 174 | 26.713 | 136.0 | 5.70 | 133.7 | 3.62 | 2.82 | | 1475. |
| 200 | 5.45 | 33.867 | 199 | 26.748 | 132.9 | 5.43 | 130.3 | 3.96 | 3.46 | | 1475. |
| 225 | 5.16 | 33.870 | 223 | 26.784 | 129.6 | 5.15 | 127.0 | 4.28 | 4.17 | | 1474. |
| 250 | 4.91 | 33.874 | 248 | 26.816 | 126.7 | 4.89 | 123.9 | 4.60 | 4.95 | | 1473. |
| 300 | 4.47 | 33.898 | 298 | 26.884 | 120.5 | 4.44 | 117.4 | 5.22 | 6.68 | | 1472. |
| 400 | 4.14 | 33.994 | 397 | 26.995 | 110.7 | 4.11 | 106.9 | 6.37 | 10.79 | | 1473. |
| 500 | 3.92 | 34.079 | 496 | 27.084 | 102.9 | 3.89 | 98.3 | 7.44 | 15.68 | | 1473. |
| 600 | 3.72 | 34.157 | 595 | 27.167 | 95.6 | 3.68 | 90.4 | 8.43 | 21.24 | | 1474. |
| 700 | 3.51 | 34.168 | 694 | 27.196 | 93.3 | 3.46 | 87.6 | 9.37 | 27.47 | | 1475. |
| 800 | 3.32 | 34.175 | 793 | 27.220 | 91.5 | 3.27 | 85.3 | 10.30 | 34.53 | | 1476. |
| 900 | 3.14 | 34.267 | 892 | 27.311 | 83.3 | 3.07 | 76.7 | 11.18 | 42.17 | | 1477. |
| 1000 | 2.97 | 34.357 | 990 | 27.397 | 75.4 | 2.90 | 68.4 | 11.97 | 49.85 | | 1478. |
| 1200 | 2.70 | 34.427 | 1188 | 27.477 | 68.5 | 2.62 | 60.8 | 13.39 | 65.73 | | 1480. |



OFFSHORE OCEANOGRAPHY GROUP
REFERENCE NO. 78- 5- 16
POSITION 50- .0 N, 145-
HYDROGRAPHIC CAST DATA

DATE 20/ 6/78 GMT 18.4
.0 W

STATION P

OBSERVED DATA

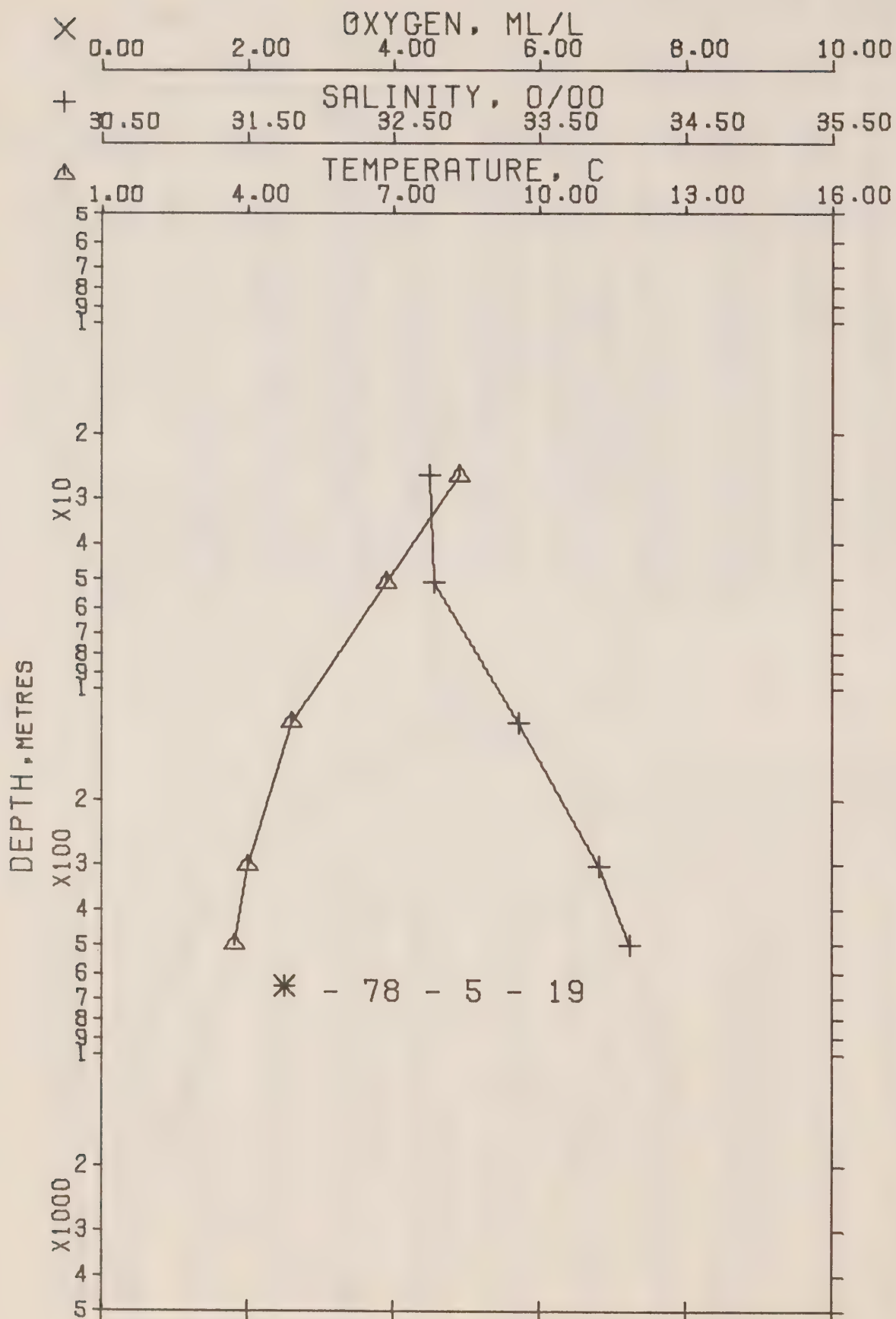
| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OxY | SOUND |
|-------|------|--------|-------|------------|-------|-------|----------------|------------|------------|------|-------|
| 0 | 8.86 | 32.748 | 0 | 25.402 | 258.5 | 8.86 | 258.5 | .00 | .00 | 7.14 | 1483. |
| 9 | 8.81 | 32.748 | 9 | 25.409 | 257.9 | 8.81 | 257.7 | .23 | .01 | 7.13 | 1483. |
| 19 | 8.03 | 32.752 | 19 | 25.529 | 246.6 | 8.03 | 246.3 | .49 | .05 | 7.20 | 1480. |
| 28 | 7.48 | 32.756 | 28 | 25.611 | 239.0 | 7.48 | 238.5 | .71 | .10 | 7.37 | 1478. |
| 46 | 6.48 | 32.785 | 46 | 25.768 | 224.2 | 6.48 | 223.6 | 1.13 | .26 | 7.41 | 1475. |
| 69 | 5.69 | 32.798 | 69 | 25.876 | 214.1 | 5.68 | 213.3 | 1.63 | .56 | 7.31 | 1472. |
| 93 | 5.17 | 32.839 | 92 | 25.969 | 205.4 | 5.16 | 204.4 | 2.12 | .96 | 7.15 | 1470. |
| 115 | 4.84 | 33.272 | 114 | 26.348 | 169.6 | 4.83 | 168.4 | 2.54 | 1.40 | 5.86 | 1470. |
| 138 | 4.78 | 33.722 | 137 | 26.711 | 135.5 | 4.77 | 134.0 | 2.69 | 1.85 | 4.21 | 1471. |
| 160 | 4.60 | 33.799 | 159 | 26.791 | 128.0 | 4.59 | 126.3 | 3.18 | 2.29 | 3.48 | 1470. |
| 183 | 4.41 | 33.821 | 182 | 26.829 | 124.6 | 4.40 | 122.7 | 3.47 | 2.80 | 3.14 | 1470. |
| 229 | 4.16 | 33.853 | 227 | 26.881 | 119.9 | 4.14 | 117.8 | 4.03 | 3.97 | 2.53 | 1470. |
| 274 | 3.93 | 33.892 | 272 | 26.936 | 115.0 | 3.91 | 112.6 | 4.56 | 5.33 | 2.09 | 1470. |
| 367 | 3.80 | 33.999 | 364 | 27.034 | 106.4 | 3.77 | 103.2 | 5.59 | 8.68 | 1.45 | 1471. |
| 464 | 3.76 | 34.092 | 460 | 27.111 | 99.8 | 3.73 | 95.8 | 6.58 | 12.90 | 1.11 | 1472. |
| 567 | 3.63 | 34.157 | 562 | 27.176 | 94.4 | 3.59 | 89.6 | 7.58 | 18.15 | .96 | 1473. |
| 805 | 3.17 | 34.300 | 798 | 27.334 | 80.6 | 3.11 | 74.6 | 9.06 | 32.62 | .56 | 1476. |
| 1007 | 2.90 | 34.380 | 997 | 27.422 | 73.0 | 2.83 | 66.1 | 11.20 | 46.85 | .52 | 1478. |
| 1208 | 2.60 | 34.446 | 1196 | 27.501 | 66.0 | 2.52 | 58.5 | 12.60 | 62.66 | .63 | 1480. |
| 1511 | 2.30 | 34.514 | 1494 | 27.580 | 59.2 | 2.20 | 50.9 | 14.48 | 88.71 | .77 | 1484. |
| 2016 | 2.00 | 34.585 | 1991 | 27.661 | 52.6 | 1.86 | 43.0 | 17.31 | 139.43 | 1.35 | 1491. |
| 2523 | 1.76 | 34.628 | 2489 | 27.714 | 48.3 | 1.58 | 37.7 | 19.86 | 198.39 | 1.96 | 1499. |
| 3033 | 1.61 | 34.661 | 2989 | 27.752 | 45.5 | 1.38 | 33.9 | 22.25 | 265.95 | 2.59 | 1507. |
| 3548 | 1.52 | 34.672 | 3492 | 27.767 | 44.8 | 1.25 | 32.1 | 24.56 | 343.60 | 3.00 | 1515. |
| 4069 | 1.52 | 34.689 | 4000 | 27.781 | 45.0 | 1.19 | 30.5 | 26.89 | 434.22 | 3.28 | 1524. |
| 4173 | 1.55 | 34.692 | 4102 | 27.781 | 45.5 | 1.21 | 30.4 | 27.37 | 454.13 | 3.31 | 1526. |
| 4268 | 1.52 | 34.685 | 4194 | 27.778 | 45.7 | 1.17 | 30.6 | 27.79 | 472.26 | 3.33 | 1527. |
| 4278 | | 34.685 | 4204 | | | | | | | 3.38 | |

OFFSHORE OCEANOGRAPHY GROUP
REFERENCE NO. 78- 5- 16
POSITION 50- .0 N, 145- .0 W
INTERPOLATED TO STANDARD PRESSURE

DATE 20/ 6/78 GMT 18.4

STATION P

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OxY | SOUND |
|-------|------|--------|-------|------------|-------|-------|----------------|------------|------------|------|-------|
| 0 | 8.86 | 32.748 | 0 | 25.402 | 258.5 | 8.86 | 258.5 | .00 | .00 | 7.14 | 1483. |
| 10 | 8.71 | 32.749 | 10 | 25.425 | 256.4 | 8.71 | 256.2 | .26 | .01 | 7.14 | 1483. |
| 20 | 7.97 | 32.752 | 20 | 25.539 | 245.7 | 7.96 | 245.4 | .51 | .05 | 7.22 | 1480. |
| 30 | 7.35 | 32.760 | 30 | 25.631 | 237.0 | 7.35 | 236.6 | .75 | .11 | 7.37 | 1478. |
| 50 | 6.33 | 32.787 | 50 | 25.789 | 222.2 | 6.33 | 221.6 | 1.21 | .30 | 7.39 | 1474. |
| 75 | 5.55 | 32.809 | 75 | 25.901 | 211.7 | 5.54 | 210.9 | 1.75 | .64 | 7.27 | 1472. |
| 100 | 5.05 | 32.994 | 99 | 26.105 | 192.6 | 5.04 | 191.5 | 2.27 | 1.11 | 6.69 | 1470. |
| 125 | 4.81 | 33.481 | 124 | 26.517 | 153.7 | 4.80 | 152.4 | 2.70 | 1.60 | 5.09 | 1470. |
| 150 | 4.68 | 33.765 | 149 | 26.756 | 131.3 | 4.67 | 129.7 | 3.05 | 2.09 | 3.80 | 1470. |
| 175 | 4.48 | 33.813 | 174 | 26.816 | 125.7 | 4.46 | 124.0 | 3.37 | 2.62 | 3.26 | 1470. |
| 200 | 4.31 | 33.834 | 199 | 26.850 | 122.7 | 4.30 | 120.8 | 3.68 | 3.21 | 2.90 | 1470. |
| 225 | 4.18 | 33.851 | 223 | 26.877 | 120.3 | 4.16 | 118.2 | 3.98 | 3.87 | 2.58 | 1470. |
| 250 | 4.05 | 33.872 | 248 | 26.908 | 117.5 | 4.03 | 115.2 | 4.26 | 4.59 | 2.31 | 1470. |
| 300 | 3.89 | 33.925 | 298 | 26.966 | 112.3 | 3.87 | 109.7 | 4.85 | 6.20 | 1.89 | 1470. |
| 400 | 3.79 | 34.033 | 397 | 27.062 | 104.0 | 3.76 | 100.5 | 5.93 | 10.04 | 1.33 | 1471. |
| 500 | 3.71 | 34.116 | 496 | 27.136 | 97.8 | 3.68 | 93.5 | 6.94 | 14.66 | 1.05 | 1473. |
| 600 | 3.56 | 34.180 | 595 | 27.202 | 92.2 | 3.51 | 87.2 | 7.89 | 19.99 | .89 | 1474. |
| 700 | 3.35 | 34.243 | 694 | 27.271 | 86.1 | 3.31 | 80.6 | 8.78 | 25.89 | .72 | 1475. |
| 800 | 3.18 | 34.297 | 793 | 27.331 | 80.8 | 3.12 | 74.9 | 9.62 | 32.26 | .57 | 1476. |
| 900 | 3.04 | 34.340 | 892 | 27.378 | 76.8 | 2.97 | 70.4 | 10.40 | 39.08 | .54 | 1477. |
| 1000 | 2.91 | 34.378 | 990 | 27.419 | 73.3 | 2.84 | 66.4 | 11.15 | 46.34 | .52 | 1478. |
| 1200 | 2.61 | 34.443 | 1188 | 27.498 | 66.3 | 2.53 | 58.8 | 12.55 | 61.98 | .62 | 1480. |
| 1500 | 2.31 | 34.512 | 1484 | 27.578 | 59.4 | 2.21 | 51.1 | 14.42 | 87.74 | .77 | 1484. |
| 2000 | 2.01 | 34.583 | 1976 | 27.659 | 52.8 | 1.87 | 43.2 | 17.23 | 137.74 | 1.33 | 1491. |
| 2500 | 1.77 | 34.626 | 2467 | 27.712 | 48.5 | 1.59 | 37.9 | 19.75 | 195.56 | 1.96 | 1498. |
| 3000 | 1.62 | 34.659 | 2956 | 27.750 | 45.7 | 1.40 | 34.1 | 22.09 | 261.30 | 2.56 | 1506. |
| 3500 | 1.53 | 34.671 | 3445 | 27.766 | 44.9 | 1.26 | 32.3 | 24.35 | 335.89 | 2.97 | 1514. |
| 4000 | 1.52 | 34.687 | 3933 | 27.779 | 44.9 | 1.20 | 30.7 | 26.59 | 421.54 | 3.24 | 1523. |
| 4100 | 1.53 | 34.690 | 4031 | 27.781 | 45.1 | 1.19 | 30.4 | 27.04 | 440.10 | 3.29 | 1525. |
| 4200 | 1.54 | 34.690 | 4128 | 27.780 | 45.6 | 1.19 | 30.4 | 27.49 | 459.30 | 3.32 | 1526. |

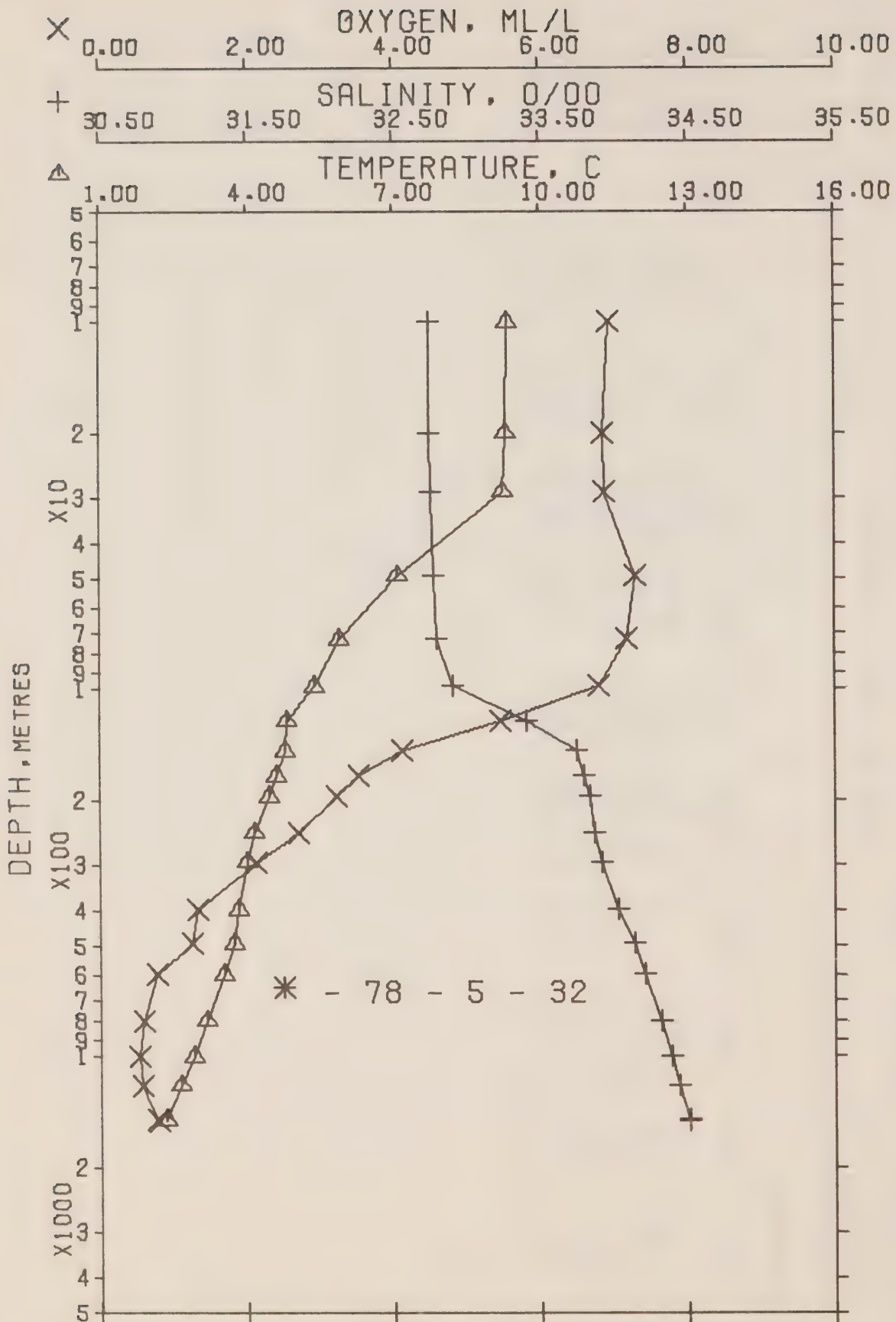


OFFSHORE OCEANOGRAPHY GROUP
 REFERENCE NO. 78- 5- 19
 POSITION 50- .0 N, 145-
 HYDROGRAPHIC CAST DATA

DATE 22/ 6/78 GMT 17.8
 .0 W STATION P

OBSERVED DATA

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|------|--------|-------|------------|-------|-------|----------------|------------|------------|-----|-------|
| 0 | 8.99 | 32.743 | 0 | 25.377 | 260.8 | 8.99 | 260.8 | .00 | .00 | | 1484. |
| 26 | 8.35 | 32.748 | 26 | 25.479 | 251.5 | 8.35 | 251.1 | .67 | .09 | | 1482. |
| 51 | 6.86 | 32.776 | 51 | 25.711 | 229.7 | 6.86 | 229.0 | 1.27 | .33 | | 1476. |
| 124 | 4.91 | 33.364 | 123 | 26.413 | 163.6 | 4.90 | 162.3 | 2.66 | 1.54 | | 1470. |
| 305 | 4.01 | 33.905 | 303 | 26.938 | 115.1 | 3.99 | 112.4 | 5.12 | 6.79 | | 1470. |
| 502 | 3.73 | 34.119 | 498 | 27.136 | 97.8 | 3.69 | 93.5 | 7.20 | 15.30 | | 1473. |



OFFSHORE OCEANOGRAPHY GROUP
REFERENCE NO. 78- 5- 32
POSITION 50- .0 N, 145-
HYDROGRAPHIC CAST DATA

DATE 26/ 6/78
.0 W

GMT 19.0

STATION P

OBSERVED DATA

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|------|--------|-------|------------|-------|-------|----------------|------------|------------|------|-------|
| 0 | 9.38 | 32.750 | 0 | 25.321 | 266.1 | 9.38 | 266.1 | .00 | .00 | 6.89 | 1485. |
| 10 | 9.35 | 32.749 | 10 | 25.325 | 265.9 | 9.35 | 265.7 | .27 | .01 | 6.95 | 1485. |
| 20 | 9.30 | 32.746 | 20 | 25.331 | 265.5 | 9.30 | 265.1 | .53 | .05 | 6.87 | 1485. |
| 29 | 9.24 | 32.755 | 29 | 25.347 | 264.1 | 9.24 | 263.6 | .78 | .12 | 6.88 | 1485. |
| 49 | 7.10 | 32.778 | 49 | 25.661 | 232.6 | 7.10 | 231.9 | 1.28 | .31 | 7.31 | 1477. |
| 73 | 5.89 | 32.802 | 73 | 25.855 | 216.2 | 5.88 | 215.3 | 1.82 | .65 | 7.19 | 1473. |
| 99 | 5.39 | 32.913 | 98 | 26.002 | 202.4 | 5.38 | 201.3 | 2.34 | 1.11 | 6.79 | 1471. |
| 123 | 4.82 | 33.413 | 122 | 26.462 | 158.9 | 4.81 | 157.6 | 2.78 | 1.60 | 5.47 | 1470. |
| 148 | 4.79 | 33.748 | 147 | 26.730 | 133.8 | 4.78 | 132.2 | 3.15 | 2.11 | 4.12 | 1471. |
| 173 | 4.60 | 33.805 | 172 | 26.796 | 127.7 | 4.59 | 125.9 | 3.48 | 2.65 | 3.52 | 1471. |
| 197 | 4.44 | 33.835 | 196 | 26.837 | 124.0 | 4.43 | 122.0 | 3.78 | 3.22 | 3.22 | 1470. |
| 248 | 4.16 | 33.869 | 246 | 26.894 | 118.9 | 4.14 | 116.6 | 4.39 | 4.61 | 2.70 | 1470. |
| 297 | 4.01 | 33.923 | 295 | 26.952 | 113.7 | 3.99 | 111.0 | 4.97 | 6.21 | 2.12 | 1470. |
| 401 | 3.81 | 34.027 | 398 | 27.055 | 104.7 | 3.78 | 101.2 | 6.10 | 10.24 | 1.31 | 1471. |
| 497 | 3.72 | 34.142 | 493 | 27.155 | 96.0 | 3.68 | 91.6 | 7.06 | 14.64 | 1.25 | 1473. |
| 603 | 3.53 | 34.211 | 598 | 27.229 | 89.6 | 3.49 | 84.6 | 9.05 | 20.15 | .77 | 1474. |
| 805 | 3.16 | 34.317 | 798 | 27.348 | 79.2 | 3.10 | 73.2 | 9.75 | 32.34 | .58 | 1476. |
| 1008 | 2.88 | 34.386 | 998 | 27.428 | 72.4 | 2.81 | 65.5 | 11.28 | 46.46 | .52 | 1478. |
| 1210 | 2.63 | 34.443 | 1198 | 27.496 | 66.6 | 2.55 | 59.0 | 12.68 | 62.35 | .56 | 1480. |
| 1503 | 2.31 | 34.513 | 1486 | 27.579 | 59.3 | 2.21 | 51.0 | 14.52 | 87.72 | .75 | 1484. |
| 1513 | 2.31 | 34.512 | 1496 | 27.578 | 59.4 | 2.21 | 51.1 | 14.58 | 68.64 | .77 | 1484. |

OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 32

DATE 26/ 6/78

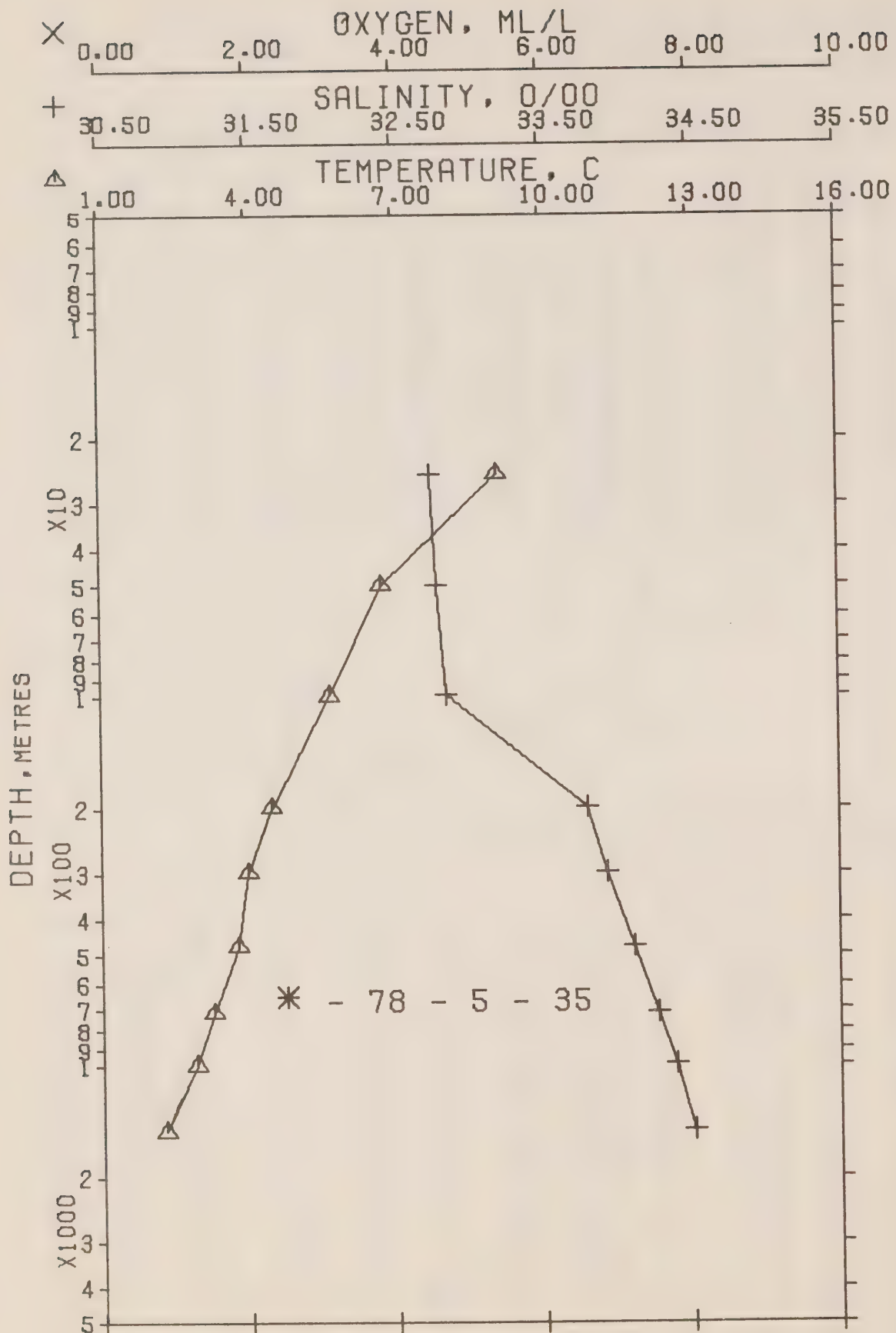
GMT 19.0

POSITION 50- .0 N, 145- .0 W

STATION P

INTERPOLATED TO STANDARD PRESSURE

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|------|--------|-------|------------|-------|-------|----------------|------------|------------|------|-------|
| 0 | 9.38 | 32.750 | 0 | 25.321 | 266.1 | 9.38 | 266.1 | .00 | .00 | 6.89 | 1485. |
| 10 | 9.35 | 32.749 | 10 | 25.325 | 265.9 | 9.35 | 265.7 | .27 | .01 | 6.95 | 1485. |
| 20 | 9.30 | 32.746 | 20 | 25.331 | 265.5 | 9.30 | 265.1 | .53 | .05 | 6.87 | 1485. |
| 30 | 9.13 | 32.756 | 30 | 25.366 | 262.3 | 9.12 | 261.8 | .80 | .12 | 6.90 | 1485. |
| 50 | 7.06 | 32.779 | 50 | 25.687 | 232.0 | 7.05 | 231.3 | 1.29 | .32 | 7.30 | 1477. |
| 75 | 5.85 | 32.810 | 75 | 25.866 | 215.2 | 5.85 | 214.3 | 1.85 | .68 | 7.16 | 1473. |
| 100 | 5.35 | 32.944 | 99 | 26.031 | 199.6 | 5.35 | 198.5 | 2.37 | 1.14 | 6.71 | 1471. |
| 125 | 4.82 | 33.445 | 124 | 26.487 | 156.5 | 4.81 | 155.2 | 2.81 | 1.65 | 5.34 | 1470. |
| 150 | 4.77 | 33.753 | 149 | 26.736 | 133.2 | 4.76 | 131.6 | 3.17 | 2.15 | 4.07 | 1471. |
| 175 | 4.59 | 33.807 | 174 | 26.799 | 127.4 | 4.57 | 125.6 | 3.50 | 2.69 | 3.49 | 1471. |
| 200 | 4.42 | 33.837 | 199 | 26.840 | 123.7 | 4.41 | 121.7 | 3.81 | 3.29 | 3.19 | 1470. |
| 225 | 4.28 | 33.855 | 223 | 26.870 | 121.0 | 4.26 | 118.9 | 4.12 | 3.95 | 2.92 | 1470. |
| 250 | 4.15 | 33.872 | 248 | 26.897 | 118.7 | 4.13 | 116.3 | 4.42 | 4.68 | 2.67 | 1470. |
| 300 | 4.00 | 33.926 | 298 | 26.955 | 113.4 | 3.98 | 110.7 | 5.00 | 6.30 | 2.10 | 1470. |
| 400 | 3.81 | 34.026 | 397 | 27.054 | 104.8 | 3.78 | 101.3 | 6.09 | 10.19 | 1.32 | 1471. |
| 500 | 3.71 | 34.144 | 496 | 27.157 | 95.8 | 3.68 | 91.4 | 7.09 | 14.78 | 1.23 | 1473. |
| 600 | 3.54 | 34.209 | 595 | 27.227 | 89.8 | 3.49 | 84.8 | 8.02 | 19.97 | .78 | 1474. |
| 700 | 3.34 | 34.266 | 694 | 27.290 | 84.2 | 3.29 | 78.7 | 8.89 | 25.74 | .67 | 1475. |
| 800 | 3.17 | 34.315 | 793 | 27.345 | 79.5 | 3.11 | 73.5 | 9.70 | 31.99 | .58 | 1475. |
| 900 | 3.02 | 34.351 | 892 | 27.388 | 75.8 | 2.96 | 69.4 | 10.48 | 38.70 | .55 | 1477. |
| 1000 | 2.89 | 34.384 | 990 | 27.426 | 72.6 | 2.82 | 65.8 | 11.22 | 45.83 | .53 | 1478. |
| 1200 | 2.64 | 34.440 | 1188 | 27.493 | 66.9 | 2.56 | 59.3 | 12.61 | 61.50 | .56 | 1480. |
| 1500 | 2.31 | 34.512 | 1484 | 27.578 | 59.4 | 2.21 | 51.1 | 14.50 | 87.49 | .75 | 1484. |

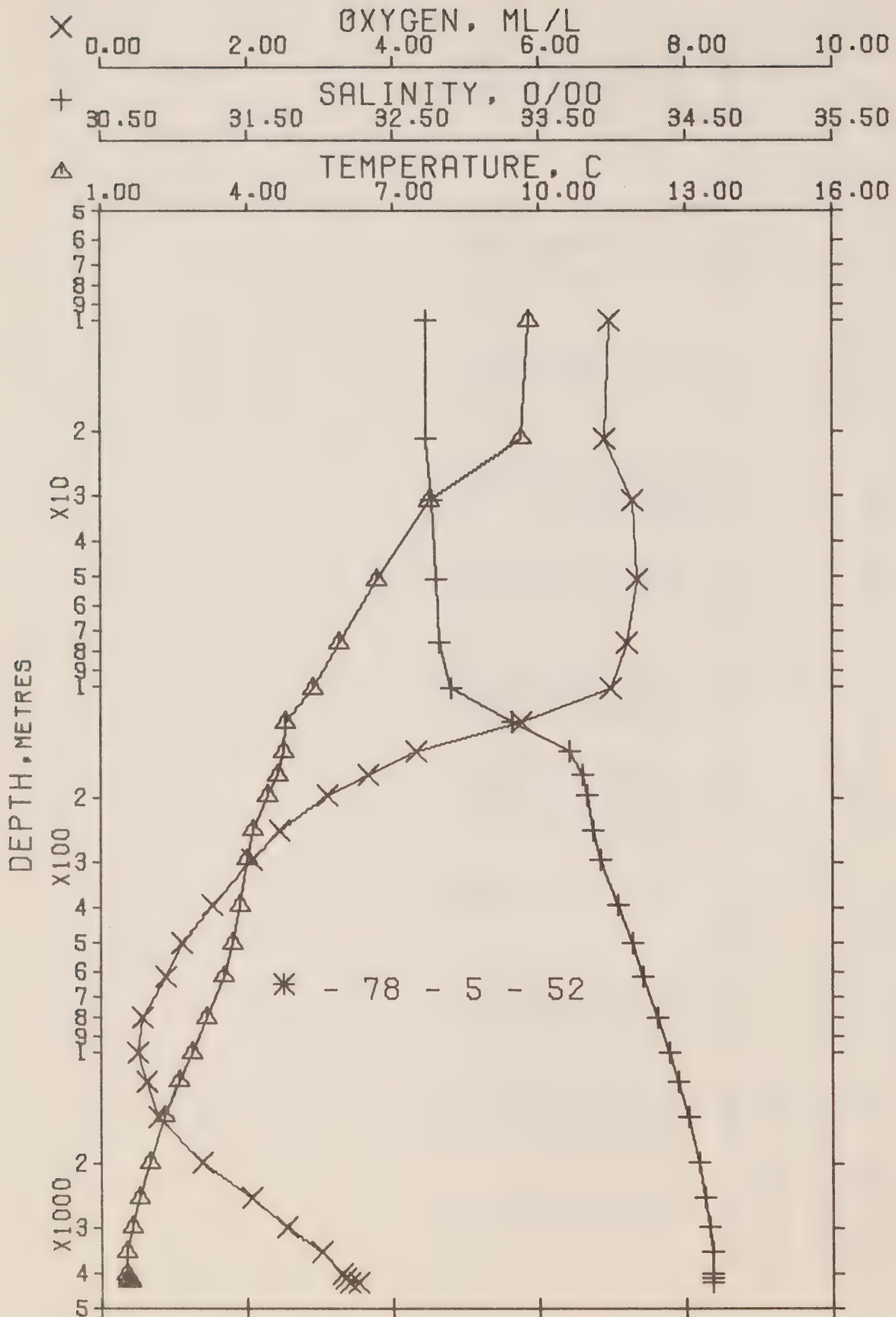


OFFSHORE OCEANOGRAPHY GROUP
 REFERENCE NO. 78- 5- 35
 POSITION 50- .0 N, 145-
 HYDROGRAPHIC CAST DATA

DATE 28/ 6/78 GMT 17.5
 .0 W STATION P

OBSERVED DATA

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|------|--------|-------|------------|-------|-------|----------------|------------|------------|-----|-------|
| 0 | 9.66 | 32.749 | 0 | 25.275 | 270.5 | 9.66 | 270.5 | .00 | .00 | | 1486. |
| 25 | 9.11 | 32.748 | 25 | 25.363 | 262.6 | 9.11 | 262.1 | .67 | .09 | | 1485. |
| 50 | 6.73 | 32.786 | 50 | 25.736 | 227.3 | 6.73 | 226.6 | 1.28 | .32 | | 1476. |
| 100 | 5.64 | 32.853 | 99 | 25.925 | 209.7 | 5.63 | 208.6 | 2.35 | 1.14 | | 1472. |
| 200 | 4.44 | 33.802 | 199 | 26.811 | 126.5 | 4.43 | 124.4 | 4.00 | 3.59 | | 1470. |
| 300 | 3.96 | 33.931 | 298 | 26.963 | 112.6 | 3.94 | 109.9 | 5.19 | 6.60 | | 1470. |
| 475 | 3.75 | 34.112 | 471 | 27.128 | 98.3 | 3.72 | 94.2 | 7.02 | 13.81 | | 1472. |
| 722 | 3.24 | 34.274 | 716 | 27.306 | 82.7 | 3.19 | 77.2 | 9.25 | 27.33 | | 1474. |
| 1003 | 2.88 | 34.386 | 993 | 27.428 | 72.3 | 2.81 | 65.5 | 11.41 | 46.29 | | 1478. |
| 1515 | 2.27 | 34.515 | 1498 | 27.584 | 58.8 | 2.17 | 50.6 | 14.74 | 88.78 | | 1484. |



OFFSHORE OCEANOGRAPHY GROUP
REFERENCE NO. 78- 5- 52
POSITION 50- .0 N, 145-
HYDROGRAPHIC CAST DATA

DATE 3/ 7/78

GMT 20.1

STATION P

OBSERVED DATA

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|------|--------|-------|------------|-------|-------|----------------|------------|------------|------|-------|
| 0 | 9.79 | 32.727 | 0 | 25.237 | 274.1 | 9.79 | 274.1 | .00 | .00 | 6.94 | 1487. |
| 10 | 9.78 | 32.729 | 10 | 25.240 | 274.0 | 9.78 | 273.8 | .28 | .01 | 6.97 | 1487. |
| 21 | 9.65 | 32.728 | 21 | 25.260 | 272.3 | 9.65 | 271.8 | .58 | .06 | 6.89 | 1487. |
| 31 | 7.75 | 32.771 | 31 | 25.585 | 241.5 | 7.75 | 241.0 | .84 | .13 | 7.28 | 1480. |
| 51 | 6.68 | 32.800 | 51 | 25.754 | 225.6 | 6.68 | 224.9 | 1.31 | .33 | 7.35 | 1476. |
| 76 | 5.89 | 32.818 | 76 | 25.868 | 215.0 | 5.88 | 214.1 | 1.86 | .69 | 7.21 | 1473. |
| 102 | 5.36 | 32.896 | 101 | 25.992 | 203.3 | 5.35 | 202.2 | 2.39 | 1.17 | 6.98 | 1471. |
| 126 | 4.78 | 33.315 | 125 | 26.389 | 165.9 | 4.77 | 164.6 | 2.83 | 1.68 | 5.76 | 1470. |
| 151 | 4.74 | 33.709 | 150 | 26.705 | 136.2 | 4.73 | 134.6 | 3.21 | 2.22 | 4.32 | 1471. |
| 175 | 4.64 | 33.802 | 174 | 26.789 | 128.4 | 4.63 | 126.5 | 3.53 | 2.74 | 3.66 | 1471. |
| 199 | 4.41 | 33.829 | 198 | 26.836 | 124.1 | 4.40 | 122.1 | 3.83 | 3.32 | 3.11 | 1470. |
| 248 | 4.13 | 33.871 | 246 | 26.898 | 118.5 | 4.11 | 116.1 | 4.42 | 4.06 | 2.45 | 1470. |
| 297 | 4.01 | 33.920 | 295 | 26.950 | 114.0 | 3.99 | 111.2 | 4.99 | 6.25 | 2.05 | 1470. |
| 397 | 3.84 | 34.037 | 394 | 27.060 | 104.3 | 3.81 | 100.7 | 6.08 | 10.10 | 1.53 | 1471. |
| 505 | 3.70 | 34.141 | 501 | 27.156 | 95.9 | 3.66 | 91.5 | 7.16 | 15.06 | 1.10 | 1473. |
| 622 | 3.51 | 34.207 | 617 | 27.227 | 89.8 | 3.47 | 84.7 | 8.25 | 21.30 | .88 | 1474. |
| 808 | 3.17 | 34.308 | 801 | 27.340 | 80.0 | 3.11 | 74.0 | 9.82 | 32.77 | .56 | 1476. |
| 1010 | 2.87 | 34.391 | 1000 | 27.433 | 71.9 | 2.80 | 65.0 | 11.35 | 46.89 | .49 | 1478. |
| 1211 | 2.60 | 34.450 | 1199 | 27.504 | 65.7 | 2.52 | 58.2 | 12.73 | 62.56 | .63 | 1480. |
| 1513 | 2.30 | 34.518 | 1496 | 27.584 | 58.9 | 2.20 | 50.6 | 14.60 | 88.50 | .79 | 1484. |
| 2018 | 1.99 | 34.588 | 1993 | 27.665 | 52.3 | 1.85 | 42.7 | 17.41 | 139.01 | 1.38 | 1491. |
| 2525 | 1.77 | 34.631 | 2491 | 27.716 | 48.2 | 1.59 | 37.6 | 19.95 | 197.74 | 2.06 | 1499. |
| 3038 | 1.62 | 34.656 | 2994 | 27.747 | 46.0 | 1.39 | 34.3 | 22.36 | 266.08 | 2.54 | 1507. |
| 3558 | 1.52 | 34.675 | 3502 | 27.770 | 44.6 | 1.24 | 31.9 | 24.71 | 345.14 | 3.01 | 1515. |
| 4088 | 1.52 | 34.683 | 4019 | 27.776 | 45.4 | 1.19 | 30.9 | 27.09 | 437.86 | 3.30 | 1524. |
| 4195 | 1.55 | 34.683 | 4123 | 27.774 | 46.2 | 1.20 | 31.0 | 27.58 | 458.54 | 3.34 | 1526. |
| 4292 | 1.54 | 34.683 | 4218 | 27.775 | 46.3 | 1.18 | 30.9 | 28.02 | 477.64 | 3.52 | 1528. |
| 4303 | | 34.683 | 4228 | | | | | | | 3.40 | |

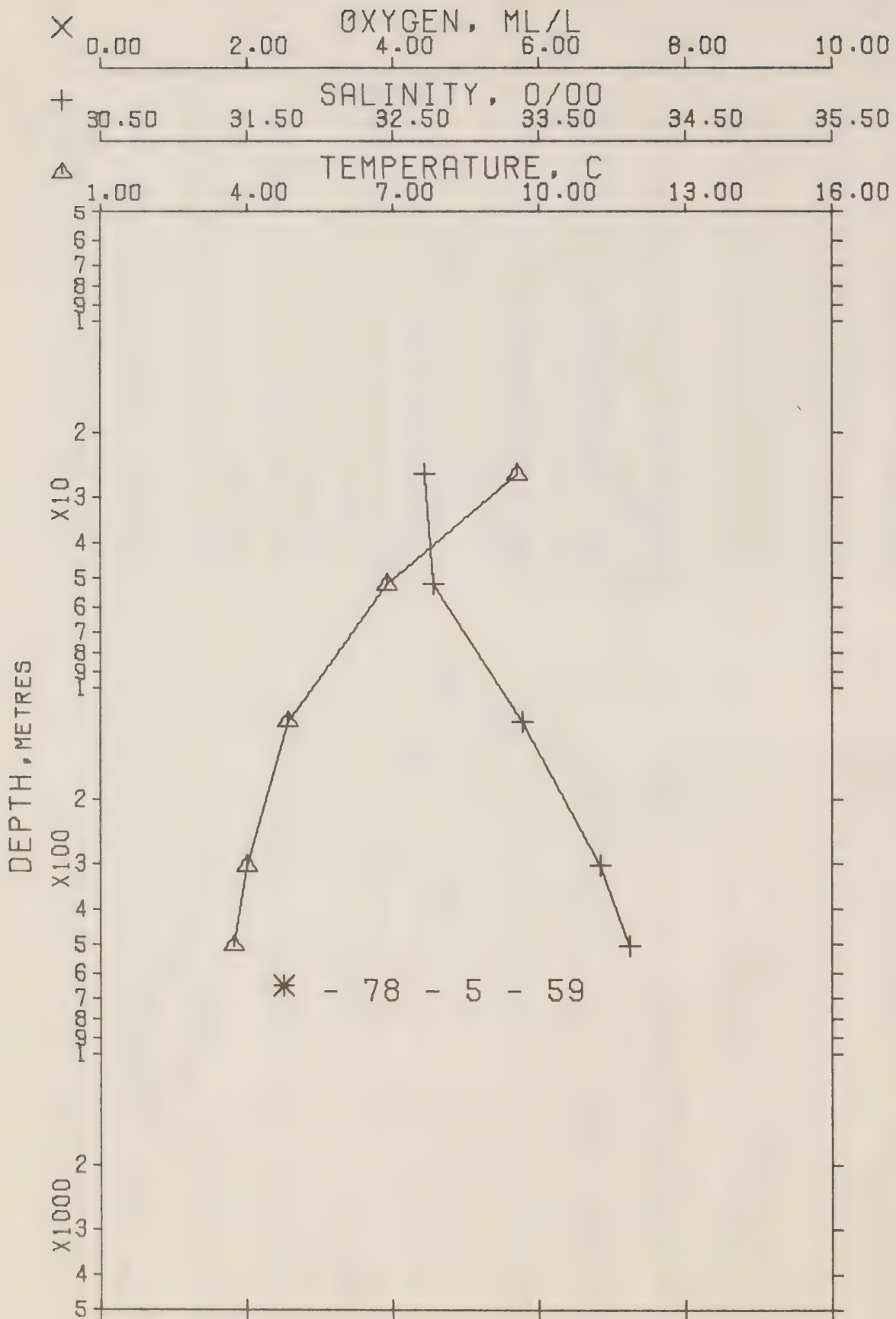
OFFSHORE OCEANOGRAPHY GROUP
REFERENCE NO. 78- 5- 52
POSITION 50- .0 N, 145- .0 W
INTERPOLATED TO STANDARD PRESSURE

DATE 3/ 7/78

GMT 20.1

STATION P

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|------|--------|-------|------------|-------|-------|----------------|------------|------------|------|-------|
| 0 | 9.79 | 32.727 | 0 | 25.237 | 274.1 | 9.79 | 274.1 | .00 | .00 | 6.94 | 1487. |
| 10 | 9.78 | 32.729 | 10 | 25.240 | 274.0 | 9.78 | 273.8 | .28 | .01 | 6.97 | 1487. |
| 20 | 9.66 | 32.728 | 20 | 25.259 | 272.4 | 9.66 | 272.0 | .55 | .06 | 6.90 | 1487. |
| 30 | 7.94 | 32.767 | 30 | 25.554 | 244.4 | 7.94 | 243.9 | .81 | .12 | 7.24 | 1480. |
| 50 | 6.74 | 32.798 | 50 | 25.745 | 226.4 | 6.73 | 225.7 | 1.28 | .31 | 7.35 | 1476. |
| 75 | 5.93 | 32.817 | 75 | 25.862 | 215.5 | 5.92 | 214.6 | 1.83 | .66 | 7.21 | 1473. |
| 100 | 5.39 | 32.892 | 99 | 25.985 | 204.0 | 5.38 | 202.9 | 2.35 | 1.13 | 6.99 | 1471. |
| 125 | 4.80 | 33.302 | 124 | 26.376 | 167.0 | 4.79 | 165.7 | 2.82 | 1.66 | 5.80 | 1470. |
| 150 | 4.74 | 33.694 | 149 | 26.693 | 137.3 | 4.73 | 135.7 | 3.20 | 2.20 | 4.37 | 1471. |
| 175 | 4.64 | 33.802 | 174 | 26.789 | 128.4 | 4.63 | 126.5 | 3.53 | 2.74 | 3.66 | 1471. |
| 200 | 4.41 | 33.830 | 199 | 26.837 | 124.0 | 4.39 | 122.0 | 3.84 | 3.34 | 3.10 | 1470. |
| 225 | 4.25 | 33.852 | 223 | 26.871 | 120.9 | 4.24 | 118.8 | 4.15 | 4.00 | 2.74 | 1470. |
| 250 | 4.12 | 33.873 | 248 | 26.901 | 118.2 | 4.11 | 115.9 | 4.44 | 4.72 | 2.43 | 1470. |
| 300 | 4.00 | 33.924 | 298 | 26.953 | 113.6 | 3.98 | 110.9 | 5.02 | 6.35 | 2.03 | 1470. |
| 400 | 3.84 | 34.040 | 397 | 27.063 | 104.0 | 3.81 | 100.5 | 6.11 | 10.22 | 1.51 | 1471. |
| 500 | 3.71 | 34.137 | 496 | 27.152 | 96.2 | 3.67 | 91.9 | 7.11 | 14.81 | 1.12 | 1473. |
| 600 | 3.54 | 34.195 | 595 | 27.215 | 90.9 | 3.50 | 85.9 | 8.04 | 20.04 | .92 | 1474. |
| 700 | 3.36 | 34.252 | 694 | 27.278 | 85.4 | 3.31 | 79.9 | 8.93 | 25.89 | .74 | 1475. |
| 800 | 3.18 | 34.304 | 793 | 27.335 | 80.4 | 3.13 | 74.4 | 9.76 | 32.22 | .57 | 1476. |
| 900 | 3.03 | 34.348 | 892 | 27.385 | 76.1 | 2.96 | 69.6 | 10.54 | 38.99 | .53 | 1477. |
| 1000 | 2.88 | 34.387 | 990 | 27.429 | 72.3 | 2.82 | 65.4 | 11.28 | 46.17 | .50 | 1478. |
| 1200 | 2.61 | 34.447 | 1188 | 27.500 | 66.1 | 2.53 | 58.6 | 12.66 | 61.63 | .62 | 1480. |
| 1500 | 2.31 | 34.515 | 1484 | 27.581 | 59.1 | 2.21 | 50.9 | 14.53 | 87.36 | .78 | 1484. |
| 2000 | 2.00 | 34.586 | 1976 | 27.662 | 52.5 | 1.86 | 42.9 | 17.32 | 137.11 | 1.36 | 1491. |
| 2500 | 1.78 | 34.629 | 2467 | 27.714 | 48.4 | 1.60 | 37.8 | 19.83 | 194.66 | 2.03 | 1498. |
| 3000 | 1.63 | 34.654 | 2956 | 27.745 | 46.2 | 1.41 | 34.6 | 22.18 | 260.65 | 2.51 | 1506. |
| 3500 | 1.53 | 34.673 | 3445 | 27.767 | 44.8 | 1.26 | 32.2 | 24.45 | 335.80 | 2.96 | 1514. |
| 4000 | 1.52 | 34.682 | 3933 | 27.775 | 45.3 | 1.20 | 31.1 | 26.69 | 421.40 | 3.25 | 1523. |
| 4100 | 1.52 | 34.683 | 4031 | 27.776 | 45.5 | 1.19 | 30.9 | 27.15 | 440.11 | 3.30 | 1524. |
| 4200 | 1.55 | 34.683 | 4128 | 27.774 | 46.2 | 1.20 | 31.0 | 27.60 | 459.55 | 3.35 | 1526. |

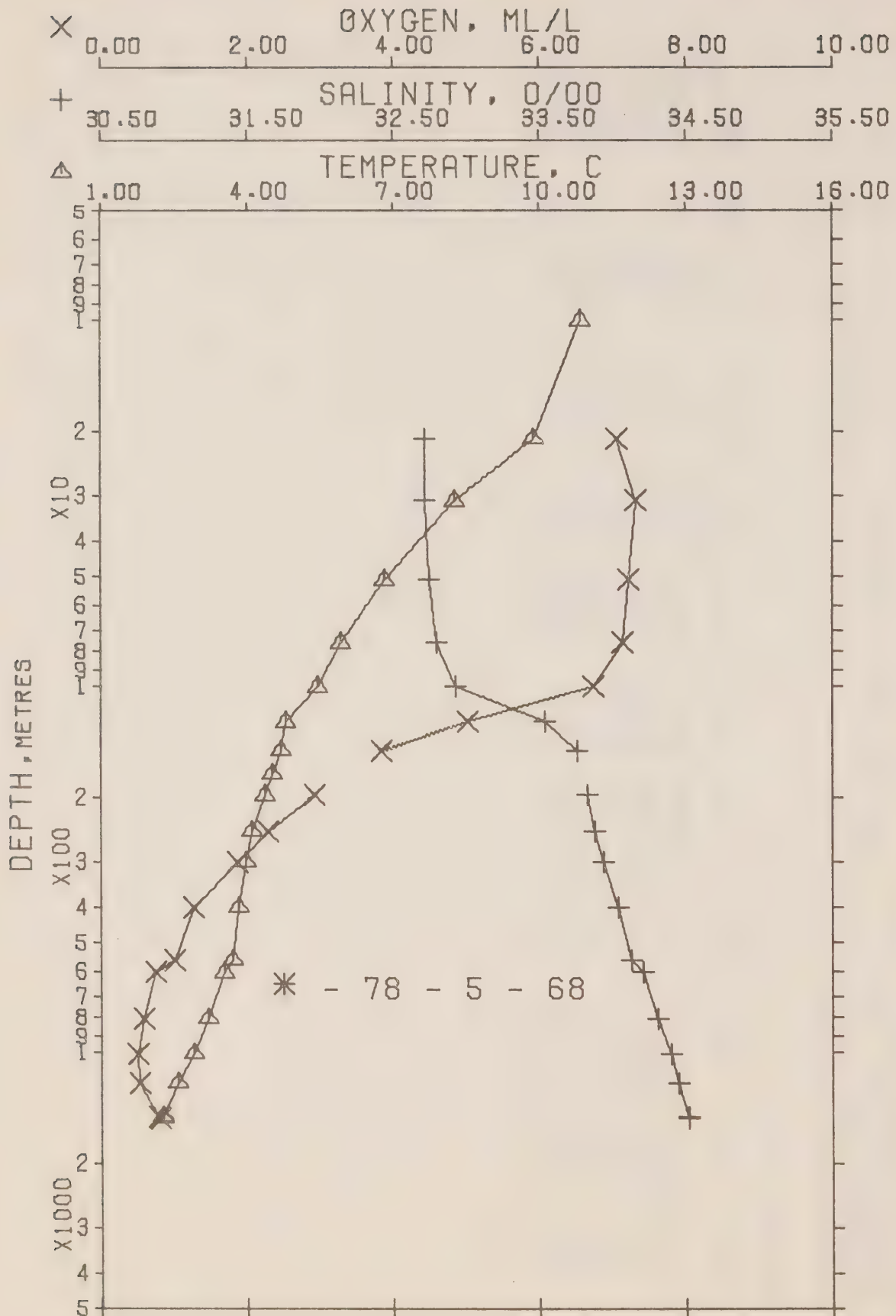


OFFSHORE OCEANOGRAPHY GROUP
 REFERENCE NO. 78- 5- 59
 POSITION 50- .0 N, 145-
 HYDROGRAPHIC CAST DATA

DATE 7/ 7/78 GMT 17.8
 .0 W STATION P

OBSERVED DATA

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|-------|--------|-------|------------|-------|-------|----------------|------------|------------|-----|-------|
| 0 | 10.51 | 32.701 | 0 | 25.095 | 287.6 | 10.51 | 287.6 | .00 | .00 | | 1489. |
| 26 | 9.54 | 32.715 | 26 | 25.268 | 271.6 | 9.54 | 271.1 | .72 | .10 | | 1486. |
| 52 | 6.88 | 32.781 | 52 | 25.712 | 229.6 | 6.88 | 228.8 | 1.37 | .35 | | 1477. |
| 124 | 4.83 | 33.385 | 123 | 26.439 | 161.1 | 4.82 | 159.8 | 2.74 | 1.55 | | 1470. |
| 307 | 4.00 | 33.917 | 305 | 26.948 | 114.2 | 3.98 | 111.4 | 5.19 | 6.82 | | 1470. |
| 507 | 3.73 | 34.123 | 503 | 27.139 | 97.6 | 3.69 | 93.2 | 7.29 | 15.49 | | 1473. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 68

DATE 10/ 7/78

GMT 19.7

POSITION 50- .0 N, 145-

.0 W

STATION P

HYDROGRAPHIC CAST DATA

OBSERVED DATA

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|-------|--------|-------|------------|-------|-------|----------------|------------|------------|------|-------|
| 0 | 11.03 | 32.711 | 0 | 25.012 | 295.5 | 11.03 | 295.5 | .00 | .00 | 6.94 | 1491. |
| 10 | 10.85 | 32.719 | 10 | 25.050 | 292.1 | 10.85 | 291.9 | .30 | .02 | 7.03 | 1491. |
| 21 | 9.87 | 32.721 | 21 | 25.219 | 276.2 | 9.87 | 275.8 | .61 | .07 | 7.06 | 1487. |
| 31 | 8.25 | 32.725 | 31 | 25.476 | 251.9 | 8.25 | 251.3 | .88 | .14 | 7.33 | 1481. |
| 51 | 6.83 | 32.751 | 51 | 25.696 | 231.2 | 6.83 | 230.5 | 1.36 | .34 | 7.23 | 1476. |
| 76 | 5.92 | 32.799 | 76 | 25.849 | 216.8 | 5.91 | 215.8 | 1.92 | .70 | 7.15 | 1473. |
| 101 | 5.43 | 32.930 | 100 | 26.011 | 201.6 | 5.42 | 200.5 | 2.43 | 1.16 | 6.73 | 1472. |
| 126 | 4.77 | 33.538 | 125 | 26.566 | 149.0 | 4.76 | 147.7 | 2.87 | 1.67 | 5.01 | 1470. |
| 150 | 4.70 | 33.761 | 149 | 26.750 | 131.8 | 4.69 | 130.2 | 3.21 | 2.14 | 3.84 | 1471. |
| 174 | 4.52 | 33.797 | 173 | 26.799 | 127.4 | 4.51 | 125.6 | 3.52 | 2.66 | 3.36 | 1470. |
| 199 | 4.36 | 33.830 | 198 | 26.842 | 123.5 | 4.35 | 121.5 | 3.84 | 3.26 | 2.92 | 1470. |
| 250 | 4.10 | 33.878 | 248 | 26.907 | 117.6 | 4.08 | 115.3 | 4.45 | 4.65 | 2.27 | 1470. |
| 303 | 3.98 | 33.939 | 301 | 26.968 | 112.3 | 3.96 | 109.5 | 5.06 | 6.38 | 1.85 | 1470. |
| 403 | 3.81 | 34.038 | 400 | 27.064 | 103.9 | 3.78 | 100.4 | 6.14 | 10.26 | 1.27 | 1471. |
| 563 | 3.70 | 34.133 | 558 | 27.150 | 96.9 | 3.66 | 92.1 | 7.74 | 18.14 | 1.00 | 1474. |
| 607 | 3.53 | 34.213 | 602 | 27.230 | 89.5 | 3.49 | 84.5 | 8.16 | 20.61 | .75 | 1474. |
| 811 | 3.20 | 34.307 | 804 | 27.336 | 80.4 | 3.14 | 74.3 | 9.87 | 33.03 | .58 | 1476. |
| 1016 | 2.88 | 34.396 | 1006 | 27.436 | 71.7 | 2.81 | 64.7 | 11.43 | 47.46 | .50 | 1478. |
| 1220 | 2.57 | 34.448 | 1207 | 27.505 | 65.6 | 2.49 | 58.1 | 12.82 | 63.32 | .53 | 1480. |
| 1513 | 2.27 | 34.518 | 1496 | 27.586 | 58.5 | 2.17 | 50.3 | 14.63 | 88.57 | .79 | 1484. |
| 1523 | 2.27 | 34.518 | 1506 | 27.586 | 58.6 | 2.17 | 50.3 | 14.69 | 89.49 | .80 | 1484. |

OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 68

DATE 10/ 7/78

GMT 19.7

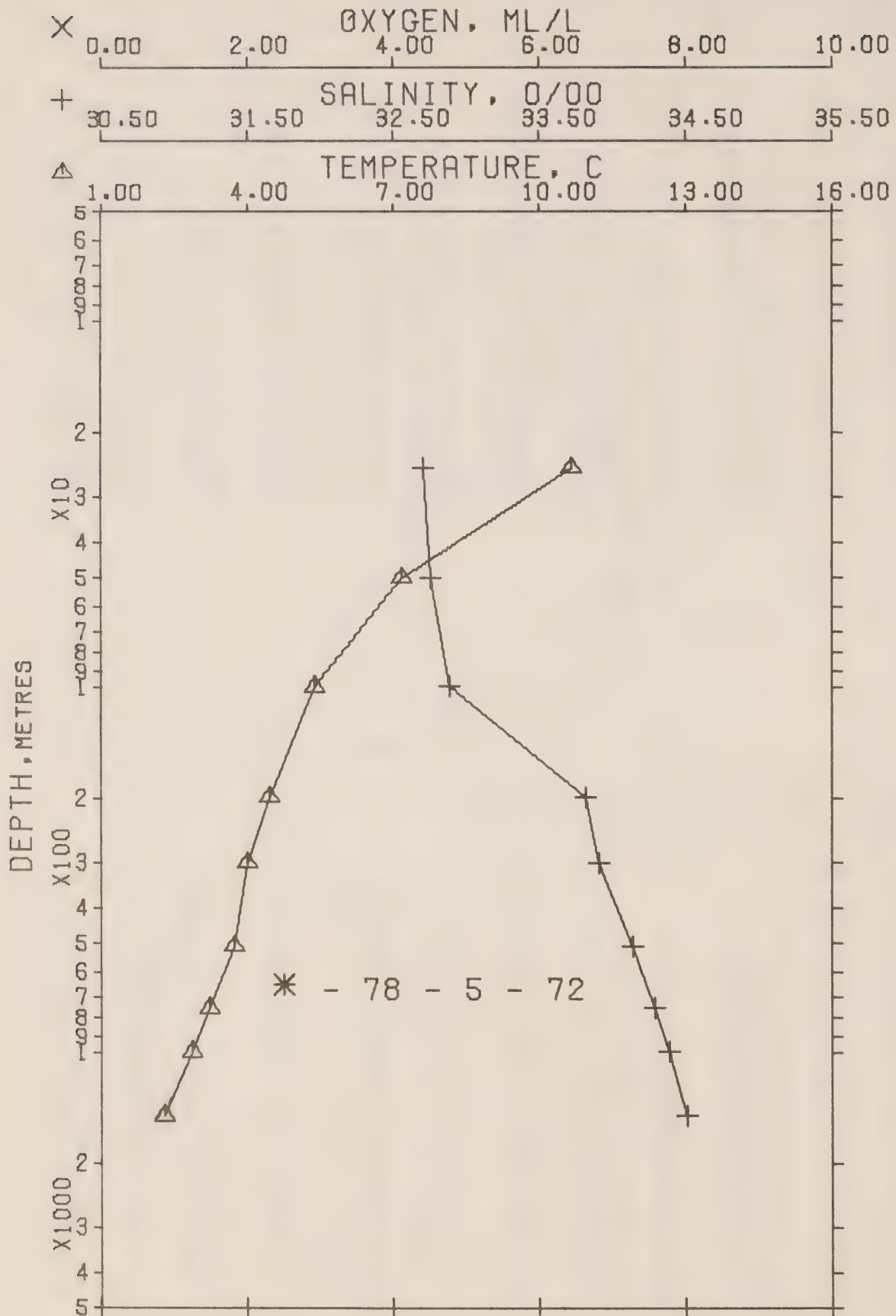
POSITION 50- .0 N, 145-

.0 W

STATION P

INTERPOLATED TO STANDARD PRESSURE

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|-------|--------|-------|------------|-------|-------|----------------|------------|------------|------|-------|
| 0 | 11.03 | 32.711 | 0 | 25.012 | 295.5 | 11.03 | 295.5 | .00 | .00 | 6.94 | 1491. |
| 10 | 10.85 | 32.719 | 10 | 25.050 | 292.1 | 10.85 | 291.9 | .30 | .02 | 7.03 | 1491. |
| 20 | 9.94 | 32.721 | 20 | 25.207 | 277.4 | 9.94 | 277.0 | .58 | .06 | 7.06 | 1488. |
| 30 | 8.41 | 32.725 | 30 | 25.452 | 254.2 | 8.41 | 253.7 | .85 | .13 | 7.30 | 1482. |
| 50 | 6.90 | 32.750 | 50 | 25.685 | 232.2 | 6.90 | 231.5 | 1.33 | .32 | 7.23 | 1477. |
| 75 | 5.96 | 32.797 | 75 | 25.842 | 217.5 | 5.96 | 216.5 | 1.89 | .68 | 7.15 | 1473. |
| 100 | 5.44 | 32.927 | 99 | 26.007 | 201.9 | 5.43 | 200.8 | 2.42 | 1.15 | 6.74 | 1472. |
| 125 | 4.79 | 33.520 | 124 | 26.550 | 150.6 | 4.78 | 149.3 | 2.86 | 1.65 | 5.07 | 1470. |
| 150 | 4.70 | 33.761 | 149 | 26.750 | 131.8 | 4.69 | 130.2 | 3.21 | 2.14 | 3.84 | 1471. |
| 175 | 4.51 | 33.798 | 174 | 26.800 | 127.3 | 4.50 | 125.5 | 3.53 | 2.68 | 3.34 | 1470. |
| 200 | 4.36 | 33.831 | 199 | 26.843 | 123.4 | 4.34 | 121.4 | 3.85 | 3.28 | 2.92 | 1470. |
| 225 | 4.22 | 33.856 | 223 | 26.877 | 120.3 | 4.20 | 118.2 | 4.15 | 3.94 | 2.57 | 1470. |
| 250 | 4.10 | 33.878 | 248 | 26.907 | 117.6 | 4.08 | 115.3 | 4.45 | 4.65 | 2.27 | 1470. |
| 300 | 3.99 | 33.936 | 298 | 26.964 | 112.6 | 3.97 | 109.8 | 5.02 | 6.27 | 1.87 | 1470. |
| 400 | 3.81 | 34.035 | 397 | 27.061 | 104.1 | 3.79 | 100.6 | 6.11 | 10.13 | 1.28 | 1471. |
| 500 | 3.74 | 34.099 | 496 | 27.119 | 99.4 | 3.70 | 95.0 | 7.12 | 14.78 | 1.10 | 1473. |
| 600 | 3.56 | 34.200 | 595 | 27.218 | 90.7 | 3.51 | 85.7 | 8.09 | 20.21 | .79 | 1474. |
| 700 | 3.37 | 34.259 | 694 | 27.282 | 85.0 | 3.32 | 79.5 | 8.95 | 25.93 | .66 | 1475. |
| 800 | 3.22 | 34.302 | 793 | 27.331 | 80.9 | 3.16 | 74.8 | 9.78 | 32.27 | .59 | 1476. |
| 900 | 3.05 | 34.348 | 892 | 27.383 | 76.4 | 2.99 | 69.9 | 10.57 | 39.08 | .54 | 1477. |
| 1000 | 2.90 | 34.390 | 990 | 27.429 | 72.3 | 2.83 | 65.4 | 11.31 | 46.28 | .51 | 1478. |
| 1200 | 2.60 | 34.443 | 1188 | 27.499 | 66.1 | 2.52 | 58.7 | 12.69 | 61.74 | .53 | 1480. |
| 1500 | 2.28 | 34.515 | 1484 | 27.583 | 58.8 | 2.18 | 50.7 | 14.56 | 87.43 | .78 | 1484. |

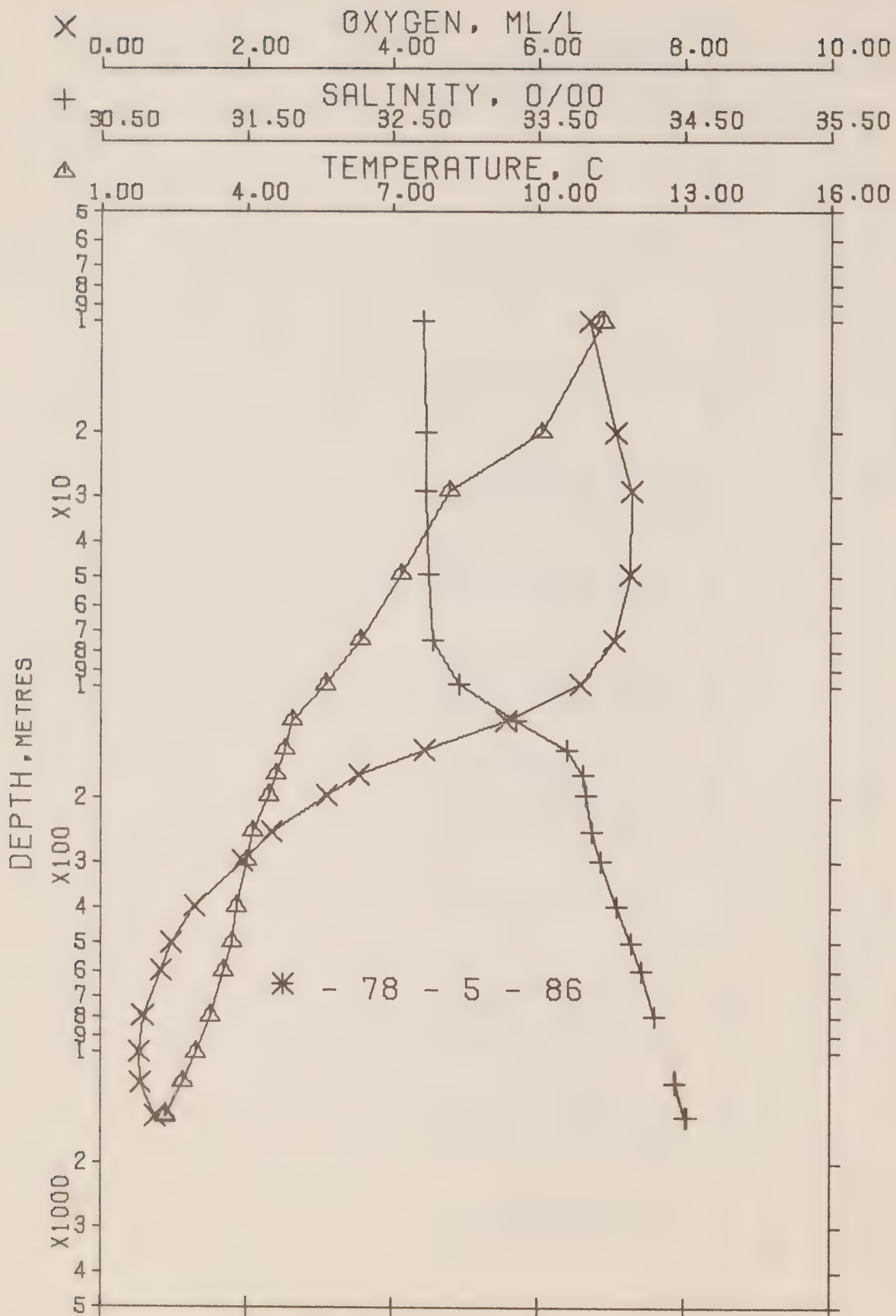


OFFSHORE OCEANOGRAPHY GROUP
 REFERENCE NO. 78- 5- 72
 POSITION 50- .0 N, 145-
 HYDROGRAPHIC CAST DATA

DATE 12/ 7/78 GMT 17.5
 .0 W STATION P

OBSERVED DATA

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|-------|--------|-------|------------|-------|-------|----------------|------------|------------|-----|-------|
| 0 | 11.21 | 32.716 | 0 | 24.984 | 298.2 | 11.21 | 298.2 | .00 | .00 | | 1492. |
| 25 | 10.65 | 32.711 | 25 | 25.079 | 289.7 | 10.65 | 289.1 | .73 | .09 | | 1490. |
| 50 | 7.17 | 32.759 | 50 | 25.656 | 234.9 | 7.17 | 234.2 | 1.39 | .34 | | 1478. |
| 100 | 5.38 | 32.885 | 99 | 25.981 | 204.4 | 5.37 | 203.3 | 2.46 | 1.16 | | 1471. |
| 200 | 4.44 | 33.825 | 199 | 26.829 | 124.7 | 4.43 | 122.7 | 4.08 | 3.56 | | 1470. |
| 302 | 3.99 | 33.915 | 300 | 26.948 | 114.2 | 3.97 | 111.4 | 5.29 | 6.65 | | 1470. |
| 513 | 3.72 | 34.136 | 509 | 27.150 | 96.5 | 3.68 | 92.1 | 7.49 | 15.76 | | 1473. |
| 759 | 3.23 | 34.289 | 752 | 27.319 | 81.7 | 3.18 | 76.0 | 9.67 | 29.80 | | 1475. |
| 1001 | 2.87 | 34.386 | 991 | 27.429 | 72.2 | 2.80 | 65.4 | 11.52 | 46.40 | | 1478. |
| 1505 | 2.28 | 34.514 | 1488 | 27.582 | 58.9 | 2.18 | 50.7 | 14.80 | 88.02 | | 1484. |



OFFSHORE OCEANOGRAPHY GROUP
REFERENCE NO. 78- 5- 86
POSITION 50- .0 N, 145-
HYDROGRAPHIC CAST DATA

DATE 17/ 7/78 GMT 18.0
.0 W

STATION P

OBSERVED DATA

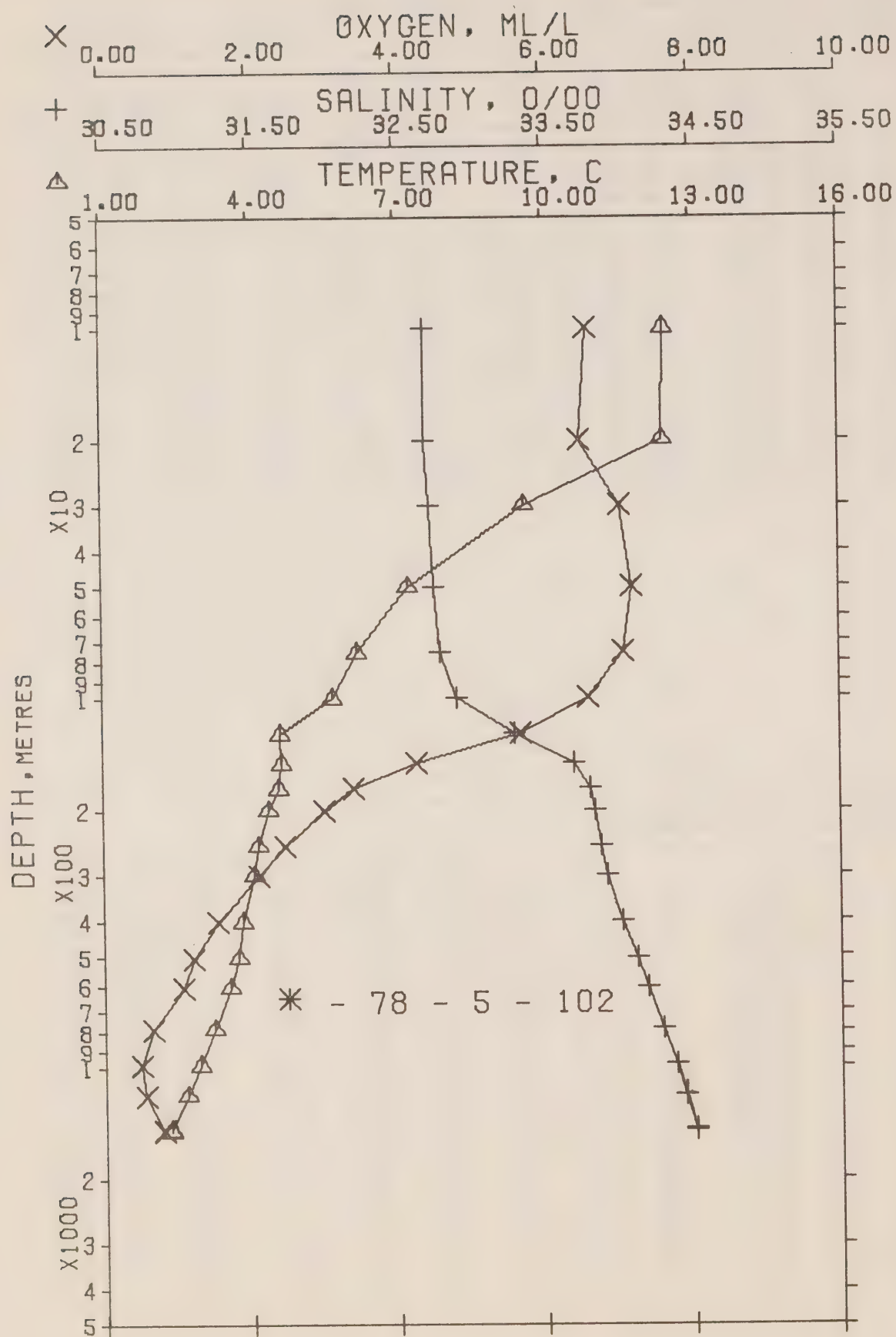
| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|-------|--------|-------|------------|-------|-------|----------------|------------|------------|------|-------|
| 0 | 11.34 | 32.712 | 0 | 24.958 | 300.7 | 11.34 | 300.7 | .00 | .00 | 6.75 | 1492. |
| 10 | 11.33 | 32.713 | 10 | 24.960 | 300.6 | 11.33 | 300.4 | .30 | .02 | 6.69 | 1492. |
| 20 | 10.05 | 32.733 | 20 | 25.198 | 278.2 | 10.05 | 277.8 | .60 | .06 | 7.07 | 1488. |
| 29 | 8.16 | 32.733 | 29 | 25.495 | 250.0 | 8.16 | 249.5 | .83 | .12 | 7.29 | 1481. |
| 49 | 7.19 | 32.752 | 49 | 25.648 | 235.7 | 7.19 | 235.0 | 1.32 | .32 | 7.25 | 1478. |
| 74 | 6.34 | 32.778 | 74 | 25.780 | 223.4 | 6.33 | 222.4 | 1.90 | .68 | 7.03 | 1475. |
| 99 | 5.61 | 32.957 | 99 | 26.011 | 201.6 | 5.60 | 200.4 | 2.42 | 1.13 | 6.58 | 1472. |
| 124 | 4.92 | 33.354 | 123 | 26.404 | 164.4 | 4.91 | 163.1 | 2.88 | 1.65 | 5.57 | 1471. |
| 149 | 4.79 | 33.699 | 148 | 26.691 | 137.4 | 4.78 | 135.8 | 3.26 | 2.18 | 4.44 | 1471. |
| 174 | 4.60 | 33.806 | 173 | 26.797 | 127.6 | 4.59 | 125.8 | 3.59 | 2.73 | 3.55 | 1471. |
| 199 | 4.44 | 33.826 | 198 | 26.830 | 124.6 | 4.43 | 122.6 | 3.91 | 3.33 | 3.10 | 1470. |
| 250 | 4.11 | 33.873 | 248 | 26.902 | 118.1 | 4.09 | 115.8 | 4.52 | 4.73 | 2.34 | 1470. |
| 300 | 3.99 | 33.930 | 298 | 26.960 | 113.0 | 3.97 | 110.3 | 5.10 | 6.36 | 1.94 | 1470. |
| 401 | 3.80 | 34.036 | 398 | 27.063 | 103.9 | 3.77 | 100.4 | 6.19 | 10.27 | 1.28 | 1471. |
| 502 | 3.69 | 34.137 | 498 | 27.154 | 96.0 | 3.65 | 91.7 | 7.20 | 14.91 | .95 | 1473. |
| 601 | 3.53 | 34.207 | 596 | 27.225 | 89.9 | 3.49 | 84.9 | 8.12 | 20.08 | .82 | 1474. |
| 803 | 3.24 | 34.302 | 796 | 27.329 | 81.2 | 3.18 | 75.0 | 9.85 | 32.40 | .57 | 1476. |
| 1011 | 2.95 | 34.378 | 1001 | 27.416 | 73.8 | 2.88 | 66.7 | 11.45 | 47.21 | .52 | 1478. |
| 1217 | 2.67 | 34.439 | 1205 | 27.489 | 67.4 | 2.59 | 59.6 | 12.91 | 63.74 | .53 | 1480. |
| 1508 | 2.32 | 34.514 | 1491 | 27.579 | 59.4 | 2.22 | 51.0 | 14.74 | 89.22 | .74 | 1484. |
| 1518 | 2.32 | 34.516 | 1501 | 27.580 | 59.3 | 2.22 | 50.9 | 14.80 | 90.14 | .74 | 1484. |

OFFSHORE OCEANOGRAPHY GROUP
REFERENCE NO. 78- 5- 86
POSITION 50- .0 N, 145-
INTERPOLATED TO STANDARD PRESSURE

DATE 17/ 7/78 GMT 18.0

STATION P

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|-------|--------|-------|------------|-------|-------|----------------|------------|------------|------|-------|
| 0 | 11.34 | 32.712 | 0 | 24.958 | 300.7 | 11.34 | 300.7 | .00 | .00 | 6.75 | 1492. |
| 10 | 11.33 | 32.713 | 10 | 24.960 | 300.6 | 11.33 | 300.4 | .30 | .02 | 6.69 | 1492. |
| 20 | 10.05 | 32.733 | 20 | 25.198 | 278.2 | 10.05 | 277.8 | .60 | .06 | 7.07 | 1488. |
| 30 | 8.11 | 32.734 | 30 | 25.504 | 249.2 | 8.11 | 248.7 | .86 | .13 | 7.29 | 1481. |
| 50 | 7.16 | 32.753 | 50 | 25.653 | 235.3 | 7.16 | 234.5 | 1.34 | .32 | 7.24 | 1478. |
| 75 | 6.32 | 32.783 | 75 | 25.786 | 222.8 | 6.31 | 221.8 | 1.92 | .69 | 7.02 | 1475. |
| 100 | 5.57 | 32.981 | 99 | 26.035 | 199.3 | 5.56 | 198.2 | 2.44 | 1.16 | 6.52 | 1472. |
| 125 | 4.91 | 33.372 | 124 | 26.419 | 163.0 | 4.90 | 161.7 | 2.90 | 1.68 | 5.51 | 1471. |
| 150 | 4.78 | 33.704 | 149 | 26.696 | 137.0 | 4.77 | 135.4 | 3.27 | 2.20 | 4.40 | 1471. |
| 175 | 4.59 | 33.807 | 174 | 26.798 | 127.5 | 4.58 | 125.7 | 3.60 | 2.75 | 3.53 | 1471. |
| 200 | 4.44 | 33.827 | 199 | 26.831 | 124.6 | 4.42 | 122.5 | 3.91 | 3.35 | 3.09 | 1470. |
| 225 | 4.26 | 33.851 | 223 | 26.869 | 121.1 | 4.25 | 119.0 | 4.22 | 4.01 | 2.69 | 1470. |
| 250 | 4.11 | 33.873 | 248 | 26.902 | 118.1 | 4.09 | 115.8 | 4.52 | 4.73 | 2.34 | 1470. |
| 300 | 3.99 | 33.930 | 298 | 26.960 | 113.0 | 3.97 | 110.3 | 5.10 | 6.36 | 1.94 | 1470. |
| 400 | 3.80 | 34.035 | 397 | 27.062 | 104.0 | 3.77 | 100.5 | 6.18 | 10.22 | 1.29 | 1471. |
| 500 | 3.69 | 34.135 | 496 | 27.152 | 96.2 | 3.66 | 91.9 | 7.18 | 14.81 | .96 | 1473. |
| 600 | 3.53 | 34.206 | 595 | 27.225 | 90.0 | 3.49 | 85.0 | 8.11 | 20.02 | .82 | 1474. |
| 700 | 3.38 | 34.257 | 694 | 27.280 | 85.3 | 3.33 | 79.7 | 8.99 | 25.81 | .69 | 1475. |
| 800 | 3.24 | 34.301 | 793 | 27.327 | 81.3 | 3.19 | 75.2 | 9.82 | 32.18 | .57 | 1476. |
| 900 | 3.10 | 34.339 | 892 | 27.372 | 77.5 | 3.03 | 70.9 | 10.61 | 39.05 | .54 | 1477. |
| 1000 | 2.96 | 34.374 | 990 | 27.412 | 74.1 | 2.89 | 67.1 | 11.37 | 46.39 | .52 | 1478. |
| 1200 | 2.69 | 34.434 | 1188 | 27.484 | 67.9 | 2.61 | 60.2 | 12.79 | 62.29 | .53 | 1480. |
| 1500 | 2.33 | 34.512 | 1484 | 27.577 | 59.6 | 2.23 | 51.2 | 14.70 | 88.53 | .73 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-102

DATE 24/ 7/78

GMT 18.4

POSITION 50- .0 N, 145-

.0 W

STATION P

HYDROGRAPHIC CAST DATA

OBSERVED DATA

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|-------|--------|-------|------------|-------|-------|----------------|------------|------------|------|-------|
| 0 | 12.49 | 32.700 | 0 | 24.735 | 321.9 | 12.49 | 321.9 | .00 | .00 | 6.45 | 1496. |
| 10 | 12.47 | 32.701 | 10 | 24.739 | 321.7 | 12.47 | 321.5 | .32 | .02 | 6.61 | 1496. |
| 20 | 12.42 | 32.701 | 20 | 24.749 | 321.0 | 12.42 | 320.5 | .65 | .07 | 6.50 | 1496. |
| 30 | 9.61 | 32.733 | 30 | 25.271 | 271.4 | 9.61 | 270.8 | .95 | .14 | 7.05 | 1487. |
| 50 | 7.24 | 32.760 | 50 | 25.647 | 235.8 | 7.24 | 235.0 | 1.46 | .35 | 7.21 | 1478. |
| 75 | 6.19 | 32.796 | 75 | 25.813 | 220.2 | 6.18 | 219.2 | 2.03 | .72 | 7.08 | 1474. |
| 101 | 5.67 | 32.915 | 100 | 25.971 | 205.4 | 5.66 | 204.3 | 2.56 | 1.20 | 6.61 | 1473. |
| 126 | 4.60 | 33.296 | 125 | 26.393 | 165.4 | 4.59 | 164.1 | 3.03 | 1.73 | 5.67 | 1469. |
| 151 | 4.64 | 33.695 | 150 | 26.705 | 136.1 | 4.63 | 134.6 | 3.41 | 2.27 | 4.27 | 1470. |
| 176 | 4.56 | 33.809 | 175 | 26.804 | 127.0 | 4.55 | 125.2 | 3.73 | 2.81 | 3.40 | 1470. |
| 201 | 4.35 | 33.836 | 200 | 26.848 | 123.0 | 4.34 | 121.0 | 4.05 | 3.41 | 3.01 | 1470. |
| 252 | 4.14 | 33.879 | 250 | 26.904 | 118.0 | 4.12 | 115.6 | 4.65 | 4.82 | 2.46 | 1470. |
| 302 | 4.07 | 33.923 | 300 | 26.946 | 114.4 | 4.05 | 111.6 | 5.24 | 6.47 | 2.10 | 1471. |
| 404 | 3.82 | 34.018 | 401 | 27.047 | 105.5 | 3.79 | 102.0 | 6.36 | 10.50 | 1.54 | 1471. |
| 507 | 3.72 | 34.123 | 503 | 27.140 | 97.4 | 3.68 | 93.1 | 7.40 | 15.35 | 1.20 | 1473. |
| 610 | 3.56 | 34.189 | 605 | 27.208 | 91.6 | 3.52 | 86.5 | 8.38 | 20.89 | 1.05 | 1474. |
| 790 | 3.22 | 34.292 | 783 | 27.323 | 81.6 | 3.17 | 75.6 | 9.93 | 31.96 | .65 | 1476. |
| 992 | 2.93 | 34.381 | 982 | 27.420 | 73.2 | 2.86 | 66.3 | 11.49 | 46.06 | .49 | 1478. |
| 1195 | 2.66 | 34.439 | 1183 | 27.490 | 67.1 | 2.58 | 59.6 | 12.91 | 61.96 | .54 | 1480. |
| 1491 | 2.31 | 34.513 | 1475 | 27.579 | 59.3 | 2.21 | 51.0 | 14.72 | 86.64 | .77 | 1484. |
| 1501 | 2.32 | 34.511 | 1485 | 27.576 | 59.6 | 2.22 | 51.3 | 14.78 | 87.56 | .77 | 1484. |

OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-102

DATE 24/ 7/78

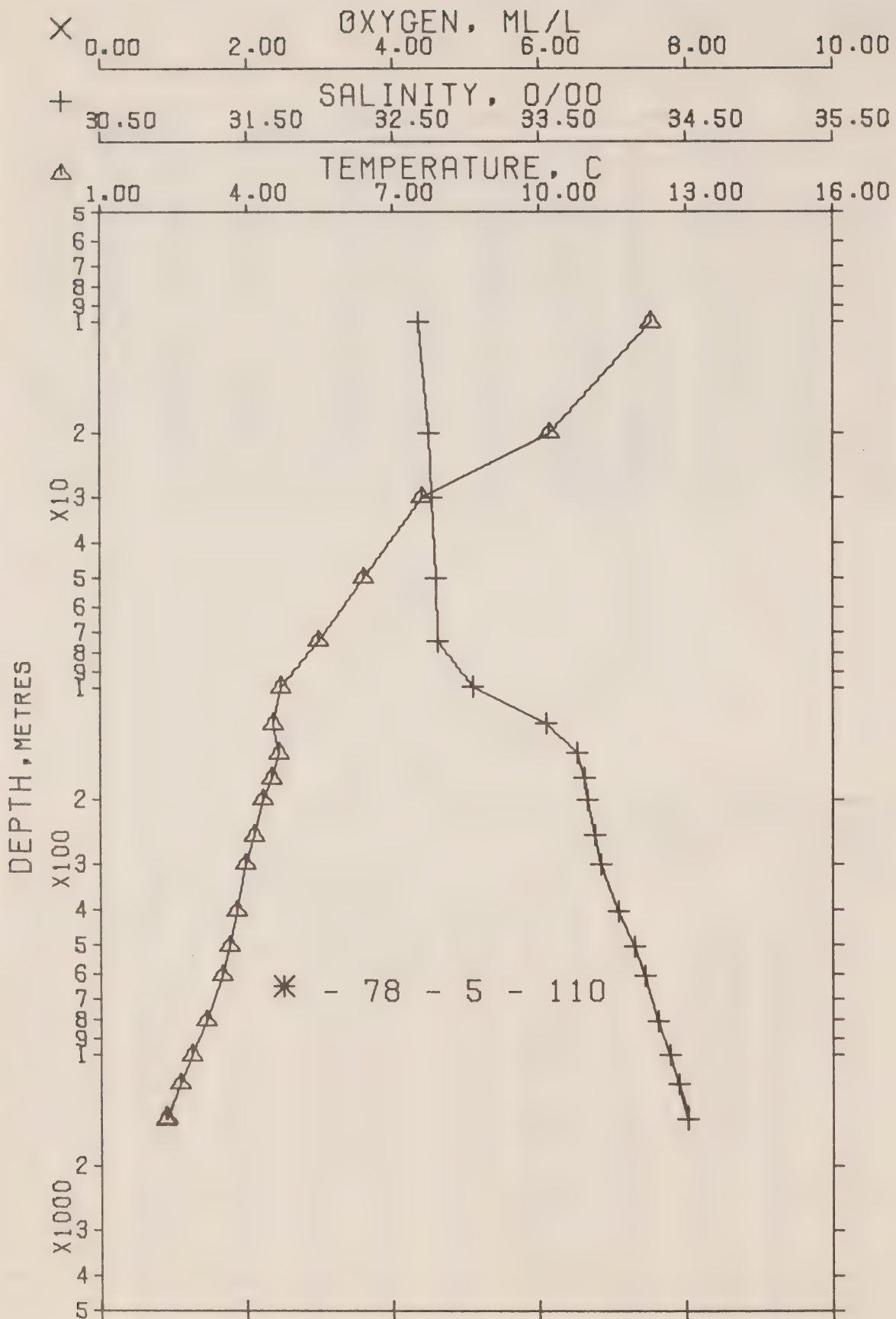
GMT 18.4

POSITION 50- .0 N, 145- .0 W

STATION P

INTERPOLATED TO STANDARD PRESSURE

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|-------|--------|-------|------------|-------|-------|----------------|------------|------------|------|-------|
| 0 | 12.49 | 32.700 | 0 | 24.735 | 321.9 | 12.49 | 321.9 | .00 | .00 | 6.45 | 1496. |
| 10 | 12.47 | 32.701 | 10 | 24.739 | 321.7 | 12.47 | 321.5 | .32 | .02 | 6.61 | 1496. |
| 20 | 12.42 | 32.701 | 20 | 24.749 | 321.0 | 12.42 | 320.5 | .65 | .07 | 6.50 | 1496. |
| 30 | 9.61 | 32.733 | 30 | 25.271 | 271.4 | 9.61 | 270.8 | .95 | .14 | 7.05 | 1487. |
| 50 | 7.24 | 32.760 | 50 | 25.647 | 235.8 | 7.24 | 235.0 | 1.46 | .35 | 7.21 | 1478. |
| 75 | 6.19 | 32.796 | 75 | 25.813 | 220.2 | 6.18 | 219.2 | 2.03 | .72 | 7.08 | 1474. |
| 100 | 5.68 | 32.912 | 99 | 25.967 | 205.8 | 5.67 | 204.6 | 2.55 | 1.18 | 6.62 | 1473. |
| 125 | 4.63 | 33.285 | 124 | 26.381 | 166.5 | 4.62 | 165.3 | 3.01 | 1.71 | 5.70 | 1469. |
| 150 | 4.64 | 33.680 | 149 | 26.693 | 137.2 | 4.63 | 135.6 | 3.39 | 2.25 | 4.32 | 1470. |
| 175 | 4.56 | 33.804 | 174 | 26.799 | 127.4 | 4.55 | 125.6 | 3.72 | 2.78 | 3.44 | 1470. |
| 200 | 4.36 | 33.835 | 199 | 26.845 | 123.2 | 4.35 | 121.2 | 4.03 | 3.38 | 3.03 | 1470. |
| 225 | 4.25 | 33.857 | 223 | 26.875 | 120.5 | 4.23 | 118.3 | 4.33 | 4.04 | 2.73 | 1470. |
| 250 | 4.15 | 33.878 | 248 | 26.902 | 118.2 | 4.13 | 115.8 | 4.63 | 4.76 | 2.47 | 1470. |
| 300 | 4.07 | 33.921 | 298 | 26.944 | 114.5 | 4.05 | 111.8 | 5.21 | 6.39 | 2.11 | 1471. |
| 400 | 3.83 | 34.015 | 397 | 27.043 | 105.8 | 3.80 | 102.3 | 6.32 | 10.32 | 1.56 | 1471. |
| 500 | 3.73 | 34.116 | 496 | 27.134 | 97.9 | 3.69 | 93.6 | 7.33 | 14.99 | 1.22 | 1473. |
| 600 | 3.57 | 34.183 | 595 | 27.202 | 92.2 | 3.53 | 87.1 | 8.28 | 20.31 | 1.07 | 1474. |
| 700 | 3.38 | 34.244 | 694 | 27.269 | 86.3 | 3.33 | 80.7 | 9.18 | 26.22 | .84 | 1475. |
| 800 | 3.20 | 34.297 | 793 | 27.328 | 81.2 | 3.15 | 75.1 | 10.01 | 32.61 | .64 | 1476. |
| 900 | 3.05 | 34.343 | 892 | 27.379 | 76.8 | 2.99 | 70.3 | 10.80 | 39.45 | .56 | 1477. |
| 1000 | 2.92 | 34.384 | 990 | 27.423 | 72.9 | 2.85 | 66.0 | 11.55 | 46.69 | .49 | 1478. |
| 1200 | 2.65 | 34.440 | 1188 | 27.492 | 67.0 | 2.57 | 59.4 | 12.95 | 62.36 | .55 | 1480. |
| 1500 | 2.32 | 34.511 | 1484 | 27.577 | 59.5 | 2.22 | 51.2 | 14.78 | 87.43 | .77 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP
 REFERENCE NO. 78- 5-110
 POSITION 50- .0 N, 145-
 HYDROGRAPHIC CAST DATA

DATE 30/ 7/78 GMT 19.8
 .0 W

STATION P

OBSERVED DATA

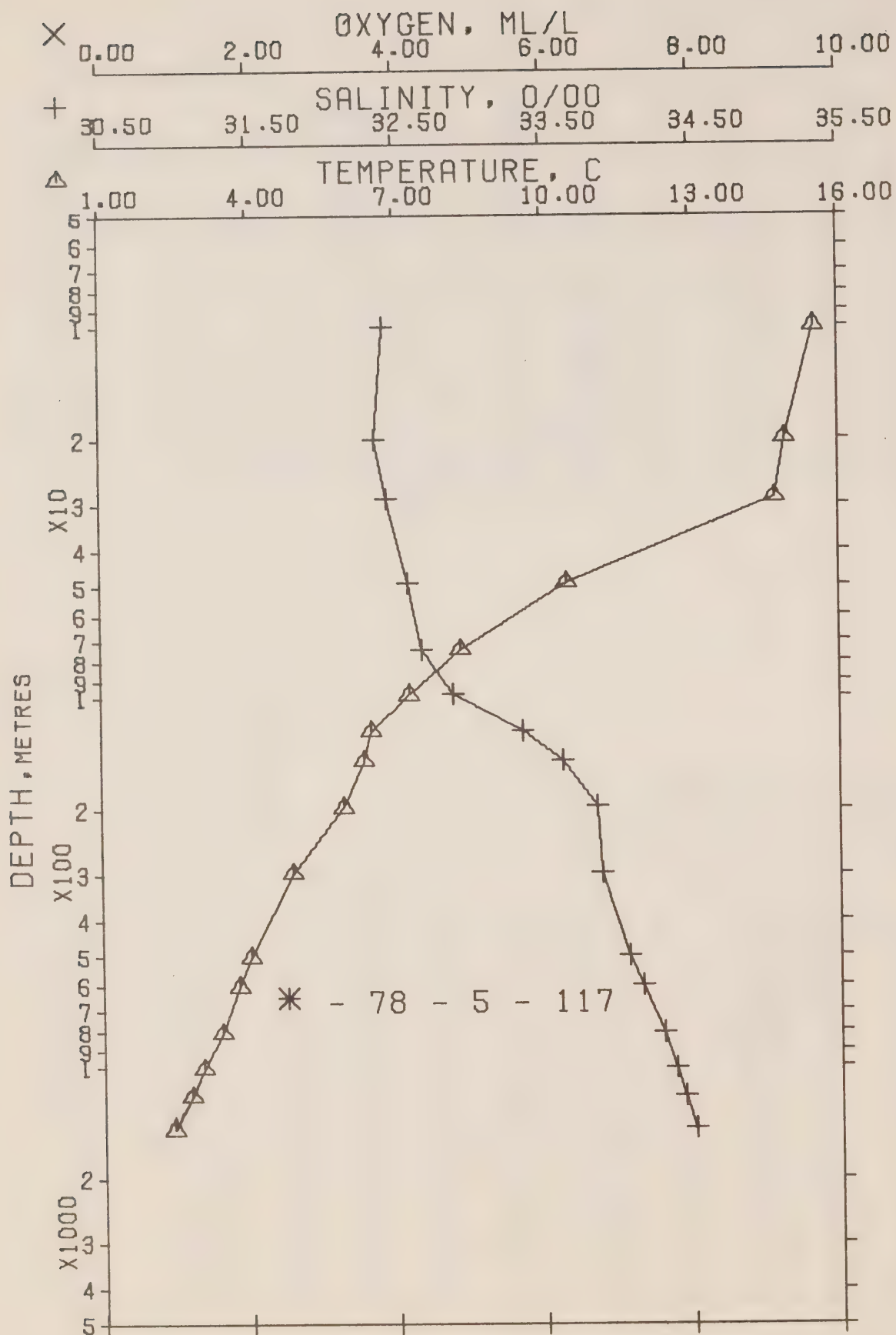
| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OxY | SOUND |
|-------|-------|--------|-------|------------|-------|-------|----------------|------------|------------|-----|-------|
| 0 | 12.30 | 32.675 | 0 | 24.752 | 320.3 | 12.30 | 320.3 | .00 | .00 | | 1496. |
| 10 | 12.29 | 32.675 | 10 | 24.754 | 320.4 | 12.29 | 320.1 | .33 | .02 | | 1496. |
| 20 | 10.20 | 32.753 | 20 | 25.189 | 279.1 | 10.20 | 278.7 | .63 | .06 | | 1489. |
| 30 | 7.59 | 32.770 | 30 | 25.607 | 239.4 | 7.59 | 238.9 | .89 | .13 | | 1479. |
| 50 | 6.41 | 32.796 | 50 | 25.786 | 222.6 | 6.41 | 221.9 | 1.34 | .31 | | 1475. |
| 74 | 5.48 | 32.807 | 74 | 25.908 | 211.1 | 5.47 | 210.3 | 1.86 | .65 | | 1471. |
| 100 | 4.68 | 33.046 | 99 | 26.187 | 184.7 | 4.67 | 183.8 | 2.36 | 1.09 | | 1469. |
| 126 | 4.55 | 33.555 | 125 | 26.604 | 145.4 | 4.54 | 144.2 | 2.79 | 1.59 | | 1469. |
| 151 | 4.67 | 33.760 | 150 | 26.753 | 131.6 | 4.66 | 130.0 | 3.14 | 2.07 | | 1470. |
| 176 | 4.51 | 33.807 | 175 | 26.807 | 126.6 | 4.50 | 124.8 | 3.46 | 2.61 | | 1470. |
| 201 | 4.34 | 33.830 | 200 | 26.844 | 123.3 | 4.33 | 121.3 | 3.78 | 3.22 | | 1470. |
| 253 | 4.16 | 33.882 | 251 | 26.904 | 118.0 | 4.14 | 115.6 | 4.40 | 4.65 | | 1470. |
| 303 | 3.96 | 33.921 | 301 | 26.956 | 113.4 | 3.94 | 110.7 | 4.98 | 6.30 | | 1470. |
| 406 | 3.80 | 34.037 | 403 | 27.064 | 103.9 | 3.77 | 100.4 | 6.10 | 10.34 | | 1471. |
| 508 | 3.65 | 34.153 | 504 | 27.171 | 94.5 | 3.61 | 90.2 | 7.11 | 15.05 | | 1473. |
| 609 | 3.49 | 34.217 | 604 | 27.237 | 88.8 | 3.45 | 83.8 | 8.03 | 20.32 | | 1474. |
| 812 | 3.16 | 34.306 | 805 | 27.339 | 80.1 | 3.10 | 74.0 | 9.74 | 32.69 | | 1476. |
| 1009 | 2.87 | 34.385 | 999 | 27.429 | 72.3 | 2.80 | 65.5 | 11.24 | 46.53 | | 1478. |
| 1207 | 2.63 | 34.448 | 1195 | 27.500 | 66.2 | 2.55 | 58.6 | 12.61 | 62.03 | | 1480. |
| 1509 | 2.34 | 34.511 | 1492 | 27.575 | 59.8 | 2.24 | 51.4 | 14.50 | 88.17 | | 1484. |
| 1519 | 2.31 | 34.512 | 1502 | 27.578 | 59.5 | 2.21 | 51.1 | 14.56 | 89.11 | | 1484. |

OFFSHORE OCEANOGRAPHY GROUP
 REFERENCE NO. 78- 5-110
 POSITION 50- .0 N, 145-
 INTERPOLATED TO STANDARD PRESSURE

DATE 30/ 7/78 GMT 19.8

STATION P

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OxY | SOUND |
|-------|-------|--------|-------|------------|-------|-------|----------------|------------|------------|-----|-------|
| 0 | 12.30 | 32.675 | 0 | 24.752 | 320.3 | 12.30 | 320.3 | .00 | .00 | | 1496. |
| 10 | 12.29 | 32.675 | 10 | 24.754 | 320.4 | 12.29 | 320.1 | .33 | .02 | | 1496. |
| 20 | 10.20 | 32.753 | 20 | 25.189 | 279.1 | 10.20 | 278.7 | .63 | .06 | | 1489. |
| 30 | 7.59 | 32.770 | 30 | 25.607 | 239.4 | 7.59 | 238.9 | .89 | .13 | | 1479. |
| 50 | 6.41 | 32.796 | 50 | 25.786 | 222.6 | 6.41 | 221.9 | 1.34 | .31 | | 1475. |
| 75 | 5.46 | 32.813 | 75 | 25.915 | 210.4 | 5.45 | 209.6 | 1.87 | .66 | | 1471. |
| 100 | 4.68 | 33.046 | 99 | 26.187 | 184.7 | 4.67 | 183.8 | 2.36 | 1.09 | | 1469. |
| 125 | 4.55 | 33.541 | 124 | 26.592 | 146.5 | 4.54 | 145.3 | 2.78 | 1.57 | | 1469. |
| 150 | 4.67 | 33.752 | 149 | 26.747 | 132.1 | 4.65 | 130.5 | 3.12 | 2.05 | | 1470. |
| 175 | 4.52 | 33.805 | 174 | 26.805 | 126.8 | 4.50 | 125.0 | 3.45 | 2.58 | | 1470. |
| 200 | 4.35 | 33.829 | 199 | 26.842 | 123.5 | 4.33 | 121.5 | 3.76 | 3.18 | | 1470. |
| 225 | 4.25 | 33.855 | 223 | 26.873 | 120.7 | 4.24 | 118.5 | 4.06 | 3.84 | | 1470. |
| 250 | 4.17 | 33.879 | 248 | 26.901 | 118.2 | 4.15 | 115.9 | 4.36 | 4.56 | | 1470. |
| 300 | 3.97 | 33.919 | 298 | 26.952 | 113.7 | 3.95 | 111.0 | 4.94 | 6.19 | | 1470. |
| 400 | 3.81 | 34.031 | 397 | 27.058 | 104.4 | 3.78 | 100.9 | 6.03 | 10.07 | | 1471. |
| 500 | 3.66 | 34.145 | 496 | 27.163 | 95.2 | 3.63 | 90.9 | 7.03 | 14.65 | | 1472. |
| 600 | 3.50 | 34.212 | 595 | 27.232 | 89.3 | 3.46 | 84.3 | 7.95 | 19.81 | | 1474. |
| 700 | 3.33 | 34.260 | 694 | 27.287 | 84.6 | 3.28 | 79.1 | 8.82 | 25.56 | | 1474. |
| 800 | 3.18 | 34.301 | 793 | 27.334 | 80.5 | 3.12 | 74.6 | 9.64 | 31.86 | | 1476. |
| 900 | 3.02 | 34.343 | 892 | 27.382 | 76.4 | 2.96 | 70.0 | 10.43 | 38.67 | | 1477. |
| 1000 | 2.88 | 34.382 | 990 | 27.425 | 72.7 | 2.81 | 65.8 | 11.17 | 45.88 | | 1478. |
| 1200 | 2.64 | 34.446 | 1188 | 27.497 | 66.4 | 2.56 | 58.9 | 12.56 | 61.43 | | 1480. |
| 1500 | 2.35 | 34.509 | 1484 | 27.573 | 60.0 | 2.25 | 51.6 | 14.45 | 87.38 | | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-117

DATE 1/ 8/78

GMT 16.4

POSITION 49-10.0 N, 132-40.0 W

STATION 7

HYDROGRAPHIC CAST DATA

OBSERVED DATA

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|-------|--------|-------|------------|-------|-------|----------------|------------|------------|-----|-------|
| 0 | 15.54 | 32.442 | 0 | 23.908 | 400.7 | 15.54 | 400.7 | .00 | .00 | | 1506. |
| 10 | 15.52 | 32.429 | 10 | 23.902 | 401.5 | 15.52 | 401.2 | .40 | .02 | | 1506. |
| 20 | 14.93 | 32.372 | 20 | 23.987 | 393.7 | 14.93 | 393.1 | .80 | .08 | | 1504. |
| 29 | 14.70 | 32.448 | 29 | 24.094 | 383.7 | 14.70 | 382.9 | 1.16 | .17 | | 1504. |
| 49 | 10.48 | 32.593 | 49 | 25.017 | 296.0 | 10.47 | 295.0 | 1.84 | .44 | | 1490. |
| 74 | 8.33 | 32.681 | 74 | 25.430 | 257.0 | 8.32 | 255.7 | 2.53 | .88 | | 1482. |
| 99 | 7.26 | 32.894 | 98 | 25.750 | 226.8 | 7.25 | 225.2 | 3.12 | 1.39 | | 1479. |
| 124 | 6.48 | 33.363 | 123 | 26.222 | 182.1 | 6.47 | 180.3 | 3.63 | 1.97 | | 1477. |
| 149 | 6.34 | 33.632 | 148 | 26.452 | 160.6 | 6.33 | 158.5 | 4.06 | 2.57 | | 1477. |
| 199 | 5.91 | 33.859 | 198 | 26.686 | 139.0 | 5.89 | 136.3 | 4.82 | 3.90 | | 1476. |
| 300 | 4.86 | 33.895 | 298 | 26.839 | 125.1 | 4.84 | 121.7 | 6.14 | 7.26 | | 1474. |
| 506 | 4.01 | 34.074 | 502 | 27.072 | 104.2 | 3.97 | 99.5 | 8.48 | 16.82 | | 1474. |
| 608 | 3.77 | 34.162 | 603 | 27.166 | 95.9 | 3.73 | 90.5 | 9.50 | 22.61 | | 1475. |
| 813 | 3.40 | 34.305 | 806 | 27.316 | 82.8 | 3.34 | 76.2 | 11.33 | 35.80 | | 1477. |
| 1015 | 3.02 | 34.383 | 1005 | 27.413 | 74.2 | 2.95 | 66.9 | 12.91 | 50.46 | | 1478. |
| 1211 | 2.78 | 34.438 | 1199 | 27.479 | 68.6 | 2.70 | 60.6 | 14.30 | 66.32 | | 1481. |
| 1488 | 2.42 | 34.514 | 1472 | 27.570 | 60.4 | 2.32 | 51.8 | 16.09 | 90.85 | | 1484. |

OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-117

DATE 1/ 8/78

GMT 16.4

POSITION 49-10.0 N, 132-40.0 W

STATION 7

INTERPOLATED TO STANDARD PRESSURE

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | THETA | SVA (THETA) | DELTA D | POT. EN | OXY | SOUND |
|-------|-------|--------|-------|------------|-------|-------|----------------|------------|------------|-----|-------|
| 0 | 15.54 | 32.442 | 0 | 23.908 | 400.7 | 15.54 | 400.7 | .00 | .00 | | 1506. |
| 10 | 15.52 | 32.429 | 10 | 23.902 | 401.5 | 15.52 | 401.2 | .40 | .02 | | 1506. |
| 20 | 14.93 | 32.372 | 20 | 23.987 | 393.7 | 14.93 | 393.1 | .80 | .08 | | 1504. |
| 30 | 14.47 | 32.456 | 30 | 24.150 | 378.4 | 14.46 | 377.6 | 1.19 | .18 | | 1503. |
| 50 | 10.40 | 32.596 | 50 | 25.033 | 294.5 | 10.39 | 293.4 | 1.86 | .45 | | 1490. |
| 75 | 8.30 | 32.687 | 75 | 25.439 | 256.1 | 8.29 | 254.8 | 2.55 | .89 | | 1482. |
| 100 | 7.21 | 32.924 | 99 | 25.780 | 223.9 | 7.20 | 222.3 | 3.15 | 1.42 | | 1479. |
| 125 | 6.47 | 33.378 | 124 | 26.235 | 180.9 | 6.46 | 179.1 | 3.66 | 2.00 | | 1477. |
| 150 | 6.33 | 33.638 | 149 | 26.458 | 160.1 | 6.32 | 157.9 | 4.08 | 2.60 | | 1477. |
| 175 | 6.10 | 33.758 | 174 | 26.582 | 148.6 | 6.09 | 146.2 | 4.47 | 3.23 | | 1477. |
| 200 | 5.90 | 33.859 | 199 | 26.687 | 138.9 | 5.88 | 136.2 | 4.83 | 3.92 | | 1476. |
| 225 | 5.60 | 33.870 | 223 | 26.732 | 134.8 | 5.58 | 131.9 | 5.17 | 4.66 | | 1476. |
| 250 | 5.33 | 33.879 | 248 | 26.772 | 131.2 | 5.31 | 128.1 | 5.50 | 5.46 | | 1475. |
| 300 | 4.86 | 33.895 | 298 | 26.839 | 125.1 | 4.84 | 121.7 | 6.14 | 7.26 | | 1474. |
| 400 | 4.39 | 33.993 | 397 | 26.968 | 113.5 | 4.36 | 109.4 | 7.33 | 11.50 | | 1474. |
| 500 | 4.03 | 34.070 | 496 | 27.067 | 104.7 | 3.99 | 100.0 | 8.42 | 16.50 | | 1474. |
| 600 | 3.79 | 34.156 | 595 | 27.159 | 96.5 | 3.74 | 91.2 | 9.43 | 22.13 | | 1475. |
| 700 | 3.59 | 34.231 | 694 | 27.239 | 89.5 | 3.54 | 83.6 | 10.36 | 28.29 | | 1476. |
| 800 | 3.42 | 34.297 | 793 | 27.307 | 83.5 | 3.36 | 77.0 | 11.22 | 34.89 | | 1477. |
| 900 | 3.23 | 34.341 | 892 | 27.361 | 78.8 | 3.16 | 71.9 | 12.03 | 41.91 | | 1477. |
| 1000 | 3.04 | 34.378 | 991 | 27.407 | 74.7 | 2.98 | 67.5 | 12.80 | 49.34 | | 1478. |
| 1200 | 2.79 | 34.435 | 1188 | 27.475 | 68.9 | 2.71 | 60.9 | 14.23 | 65.37 | | 1481. |

Results of STD Observations
(P-78-5)

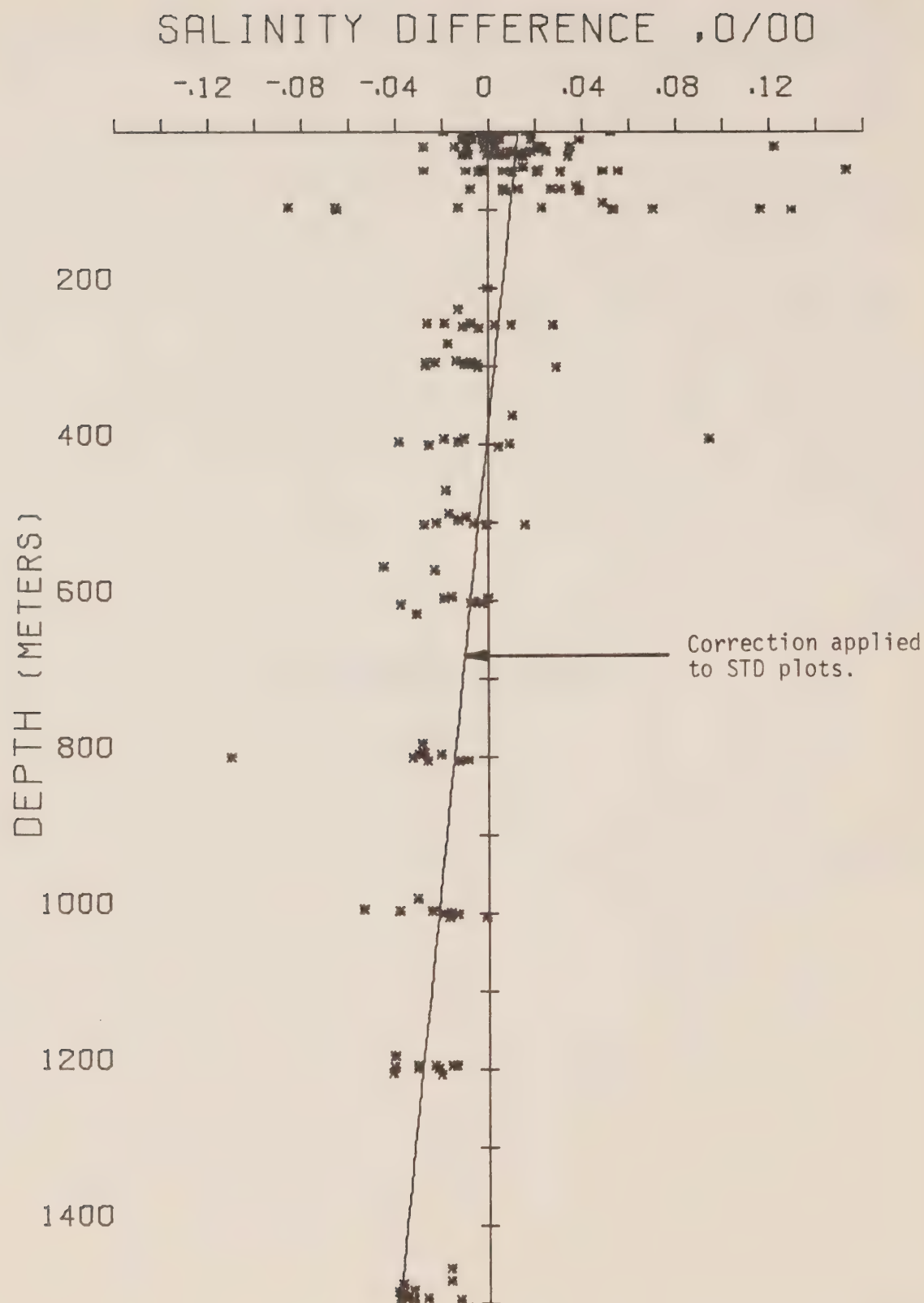


Figure 7. Salinity difference between hydro data and STD.

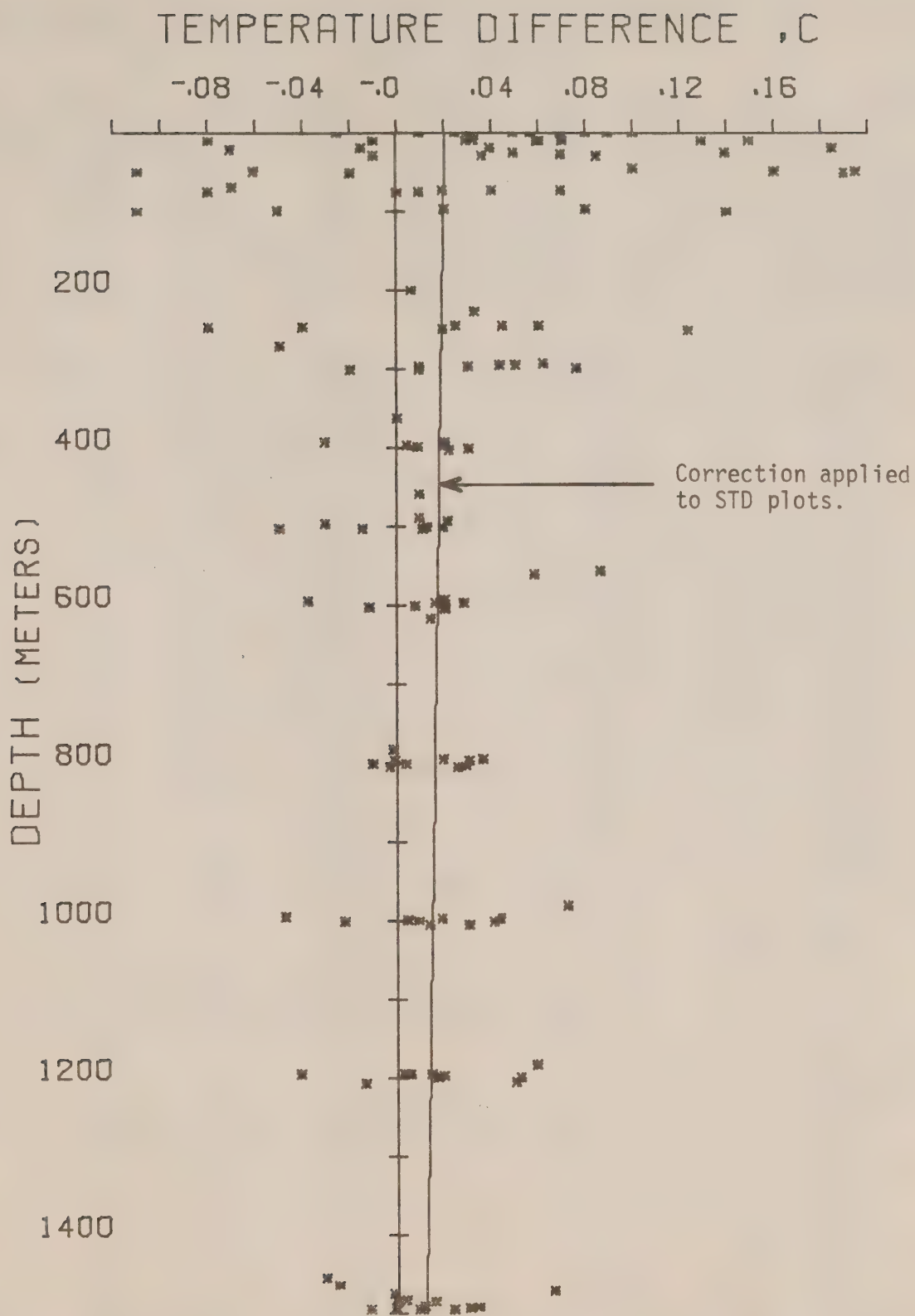


Figure 8. Temperature difference between hydro data and STD.



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 1

DATE 16/ 6/78

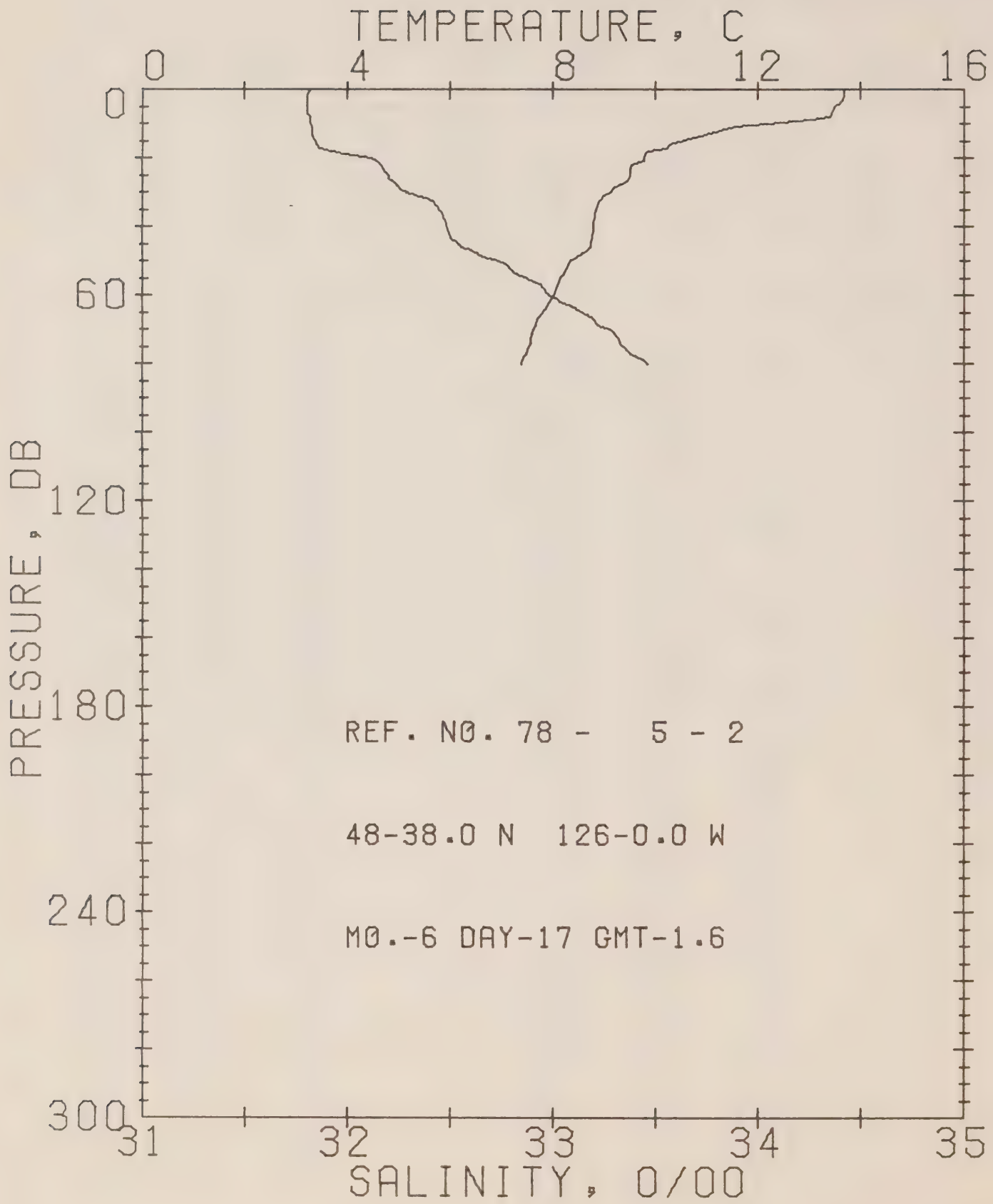
POSITION 48-33.0N, 125-33.0W GMT 23.9

RESULTS OF STP CAST 77 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 13.25 | 31.77 | 0 | 23.87 | 404.4 | .00 | .00 | 1498. |
| 10 | 11.40 | 31.87 | 10 | 24.29 | 364.2 | .39 | .02 | 1492. |
| 20 | 9.66 | 32.18 | 20 | 24.83 | 313.1 | .73 | .07 | 1486. |
| 30 | 8.90 | 32.40 | 30 | 25.12 | 285.5 | 1.03 | .15 | 1483. |
| 50 | 8.47 | 32.67 | 50 | 25.40 | 259.3 | 1.57 | .37 | 1483. |
| 75 | 7.59 | 33.20 | 75 | 25.94 | 208.3 | 2.15 | .73 | 1480. |

| PRES | DEPTH | TEMP | SAL | PRES | DEPTH | TEMP | SAL |
|------|-------|-------|-------|------|-------|------|-------|
| | 0. | 13.25 | 31.77 | | 48. | 8.60 | 32.62 |
| | 2. | 12.83 | 31.78 | | 49. | 8.53 | 32.65 |
| | 3. | 12.68 | 31.78 | | 50. | 8.45 | 32.68 |
| | 4. | 12.64 | 31.78 | | 51. | 8.40 | 32.72 |
| | 5. | 12.31 | 31.80 | | 52. | 8.31 | 32.75 |
| | 6. | 12.01 | 31.80 | | 53. | 8.28 | 32.78 |
| | 8. | 11.87 | 31.82 | | 54. | 8.21 | 32.81 |
| | 9. | 11.67 | 31.83 | | 55. | 8.17 | 32.83 |
| | 10. | 11.39 | 31.87 | | 57. | 8.12 | 32.87 |
| | 11. | 11.27 | 31.93 | | 58. | 8.09 | 32.90 |
| | 12. | 11.01 | 31.93 | | 59. | 8.04 | 32.92 |
| | 14. | 10.85 | 31.97 | | 60. | 8.01 | 32.94 |
| | 15. | 10.77 | 31.98 | | 61. | 8.00 | 32.96 |
| | 17. | 10.69 | 32.00 | | 62. | 7.97 | 32.96 |
| | 18. | 10.61 | 32.02 | | 63. | 7.94 | 32.98 |
| | 19. | 10.39 | 32.06 | | 65. | 7.90 | 33.01 |
| | 20. | 9.58 | 32.19 | | 66. | 7.80 | 33.04 |
| | 21. | 9.45 | 32.27 | | 67. | 7.78 | 33.05 |
| | 22. | 9.37 | 32.29 | | 69. | 7.71 | 33.08 |
| | 23. | 9.33 | 32.32 | | 70. | 7.68 | 33.11 |
| | 24. | 9.31 | 32.35 | | 71. | 7.64 | 33.13 |
| | 26. | 9.20 | 32.37 | | 72. | 7.62 | 33.14 |
| | 28. | 9.05 | 32.39 | | 73. | 7.61 | 33.17 |
| | 29. | 8.95 | 32.39 | | 74. | 7.60 | 33.18 |
| | 30. | 8.89 | 32.40 | | 75. | 7.58 | 33.21 |
| | 31. | 8.84 | 32.41 | | 76. | 7.56 | 33.21 |
| | 32. | 8.81 | 32.42 | | 77. | 7.55 | 33.22 |
| | 33. | 8.79 | 32.43 | | 78. | 7.51 | 33.24 |
| | 34. | 8.76 | 32.46 | | 79. | 7.47 | 33.26 |
| | 35. | 8.74 | 32.49 | | 80. | 7.42 | 33.29 |
| | 36. | 8.75 | 32.52 | | 81. | 7.41 | 33.30 |
| | 37. | 8.76 | 32.54 | | 82. | 7.26 | 33.38 |
| | 38. | 8.77 | 32.54 | | 83. | 7.18 | 33.42 |
| | 41. | 8.77 | 32.55 | | 84. | 7.13 | 33.46 |
| | 42. | 8.77 | 32.55 | | 85. | 7.00 | 33.55 |
| | 43. | 8.76 | 32.56 | | 86. | 6.97 | 33.58 |
| | 45. | 8.76 | 32.56 | | 87. | 6.95 | 33.58 |
| | 46. | 8.74 | 32.58 | | 88. | 6.94 | 33.59 |
| | 47. | 8.67 | 32.60 | | | | |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 2

DATE 17/ 6/78

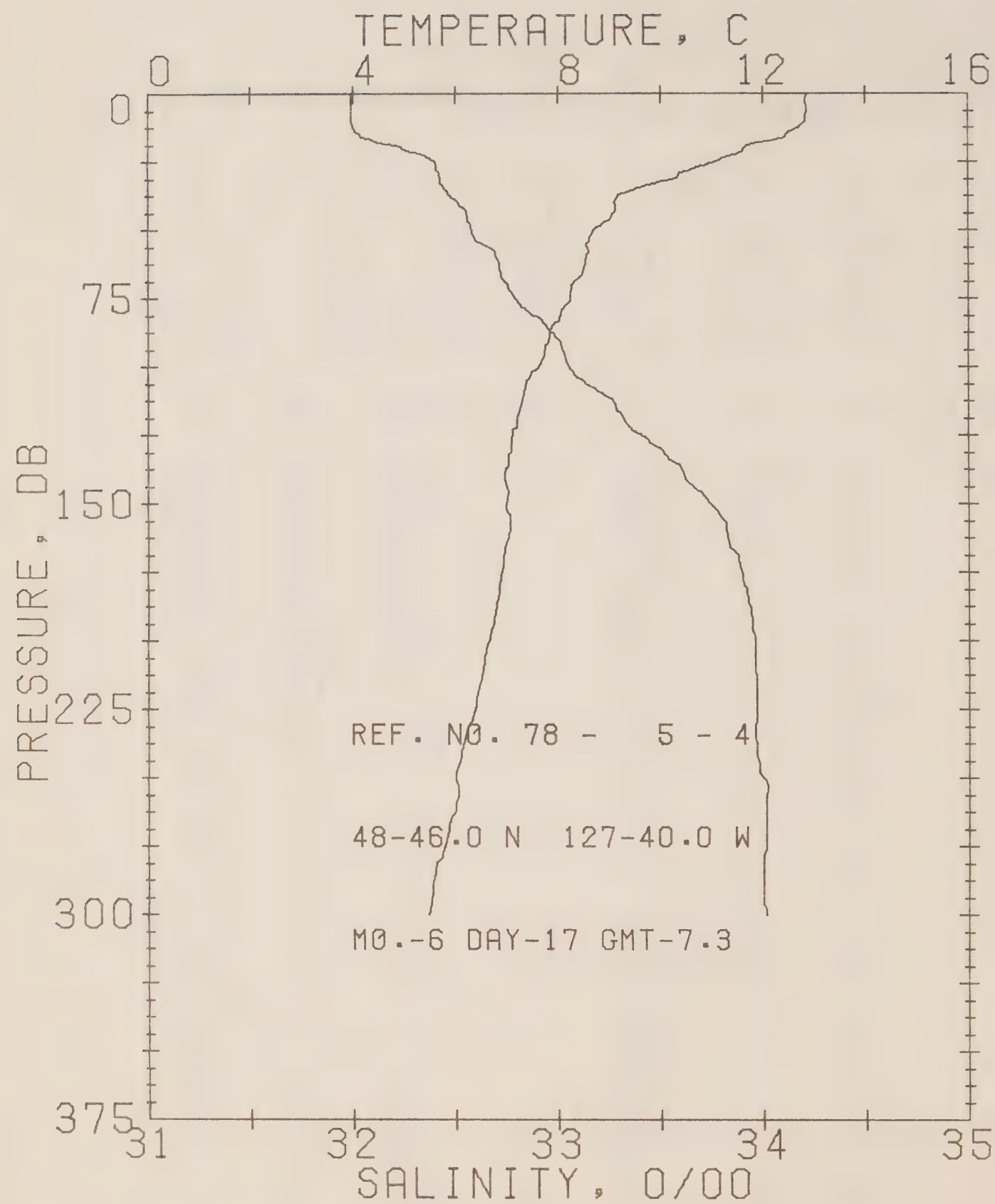
POSITION 48-38.0N, 126- .0W GMT 1.6

RESULTS OF STP CAST 67 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 13.68 | 31.82 | 0 | 23.82 | 408.9 | .00 | .00 | 1499. |
| 10 | 12.23 | 31.82 | 10 | 24.10 | 382.2 | .41 | .02 | 1494. |
| 20 | 9.80 | 32.11 | 20 | 24.75 | 320.6 | .76 | .07 | 1486. |
| 30 | 9.16 | 32.28 | 30 | 24.99 | 297.9 | 1.07 | .15 | 1484. |
| 50 | 8.39 | 32.71 | 50 | 25.44 | 255.4 | 1.62 | .38 | 1482. |
| 75 | 7.55 | 33.34 | 75 | 26.06 | 197.2 | 2.18 | .73 | 1480. |

| PRES | DEPTH | TEMP | SAL | PRES | DEPTH | TEMP | SAL |
|------|-------|-------|-------|------|-------|------|-------|
| | 0. | 13.68 | 31.82 | | 41. | 8.80 | 32.49 |
| | 2. | 13.67 | 31.81 | | 43. | 8.77 | 32.50 |
| | 3. | 13.64 | 31.81 | | 45. | 8.75 | 32.54 |
| | 4. | 13.59 | 31.81 | | 46. | 8.75 | 32.55 |
| | 5. | 13.50 | 31.81 | | 47. | 8.70 | 32.60 |
| | 6. | 13.46 | 31.81 | | 48. | 8.55 | 32.63 |
| | 7. | 13.45 | 31.81 | | 49. | 8.47 | 32.65 |
| | 8. | 13.42 | 31.82 | | 50. | 8.36 | 32.73 |
| | 9. | 13.04 | 31.82 | | 51. | 8.33 | 32.77 |
| | 10. | 12.19 | 31.82 | | 52. | 8.29 | 32.79 |
| | 11. | 11.58 | 31.83 | | 53. | 8.24 | 32.81 |
| | 13. | 10.98 | 31.83 | | 54. | 8.21 | 32.83 |
| | 16. | 10.29 | 31.85 | | 55. | 8.17 | 32.86 |
| | 17. | 10.23 | 31.86 | | 56. | 8.14 | 32.91 |
| | 18. | 9.87 | 31.92 | | 57. | 8.11 | 32.94 |
| | 19. | 9.82 | 31.98 | | 59. | 8.06 | 32.97 |
| | 20. | 9.80 | 32.12 | | 60. | 8.03 | 32.98 |
| | 21. | 9.79 | 32.14 | | 61. | 7.99 | 33.01 |
| | 22. | 9.56 | 32.16 | | 62. | 7.95 | 33.03 |
| | 23. | 9.52 | 32.17 | | 63. | 7.90 | 33.09 |
| | 24. | 9.52 | 32.18 | | 64. | 7.88 | 33.11 |
| | 25. | 9.51 | 32.20 | | 66. | 7.76 | 33.17 |
| | 26. | 9.50 | 32.20 | | 67. | 7.71 | 33.19 |
| | 27. | 9.46 | 32.22 | | 69. | 7.67 | 33.22 |
| | 28. | 9.31 | 32.24 | | 70. | 7.63 | 33.28 |
| | 29. | 9.19 | 32.25 | | 71. | 7.61 | 33.30 |
| | 30. | 9.16 | 32.29 | | 73. | 7.58 | 33.32 |
| | 31. | 9.02 | 32.33 | | 74. | 7.56 | 33.33 |
| | 32. | 8.95 | 32.40 | | 76. | 7.52 | 33.36 |
| | 33. | 8.91 | 32.42 | | 77. | 7.49 | 33.38 |
| | 35. | 8.85 | 32.45 | | 78. | 7.43 | 33.41 |
| | 36. | 8.84 | 32.46 | | 79. | 7.41 | 33.44 |
| | 37. | 8.82 | 32.47 | | 80. | 7.39 | 33.46 |
| | 39. | 8.81 | 32.48 | | | | |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 4

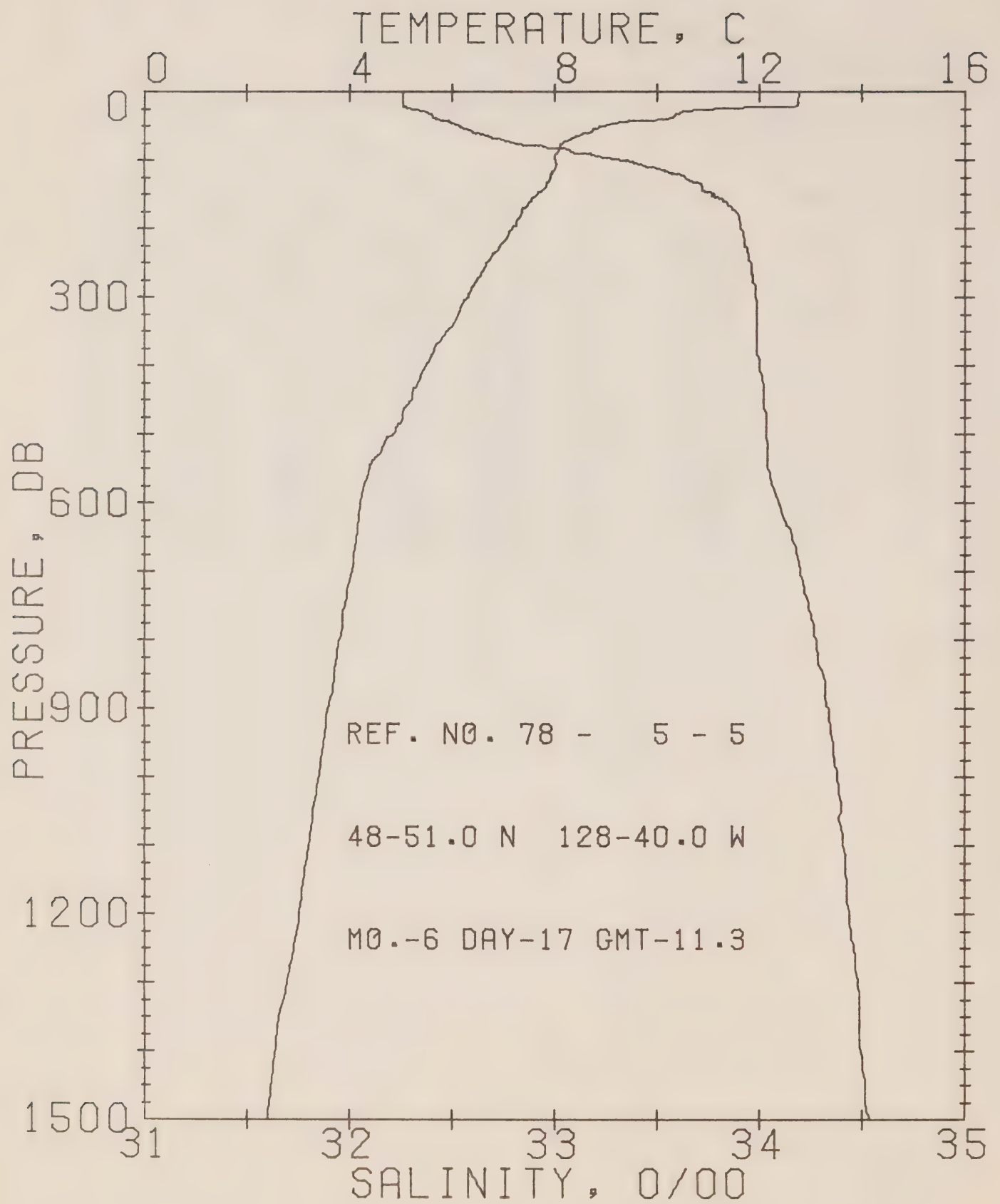
DATE 17/ 6/78

POSITION 48-46.0N, 127-40.0W GMT 7.3

RESULTS OF STP CAST 190 POINTS TAKEN FROM ANALOG TRACE

BISETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 12.85 | 31.99 | 0 | 24.12 | 380.8 | .00 | .00 | 1497. |
| 10 | 12.82 | 31.99 | 10 | 24.12 | 380.4 | .38 | .02 | 1497. |
| 20 | 11.63 | 32.24 | 20 | 24.54 | 341.0 | .75 | .08 | 1493. |
| 30 | 10.36 | 32.42 | 30 | 24.90 | 306.5 | 1.07 | .16 | 1489. |
| 50 | 8.72 | 32.58 | 50 | 25.29 | 269.8 | 1.64 | .39 | 1483. |
| 75 | 8.24 | 32.79 | 75 | 25.53 | 247.9 | 2.28 | .80 | 1482. |
| 100 | 7.63 | 33.05 | 99 | 25.82 | 220.4 | 2.86 | 1.31 | 1481. |
| 125 | 7.13 | 33.39 | 124 | 26.16 | 188.7 | 3.37 | 1.89 | 1479. |
| 150 | 7.01 | 33.73 | 149 | 26.44 | 161.9 | 3.80 | 2.50 | 1480. |
| 175 | 6.92 | 33.89 | 174 | 26.58 | 149.0 | 4.19 | 3.14 | 1480. |
| 200 | 6.67 | 33.96 | 199 | 26.67 | 141.2 | 4.55 | 3.83 | 1480. |
| 225 | 6.39 | 33.97 | 223 | 26.71 | 137.1 | 4.90 | 4.59 | 1479. |
| 250 | 6.00 | 33.98 | 248 | 26.77 | 131.5 | 5.24 | 5.40 | 1478. |
| 300 | 5.49 | 34.01 | 298 | 26.86 | 124.0 | 5.88 | 7.19 | 1477. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 5

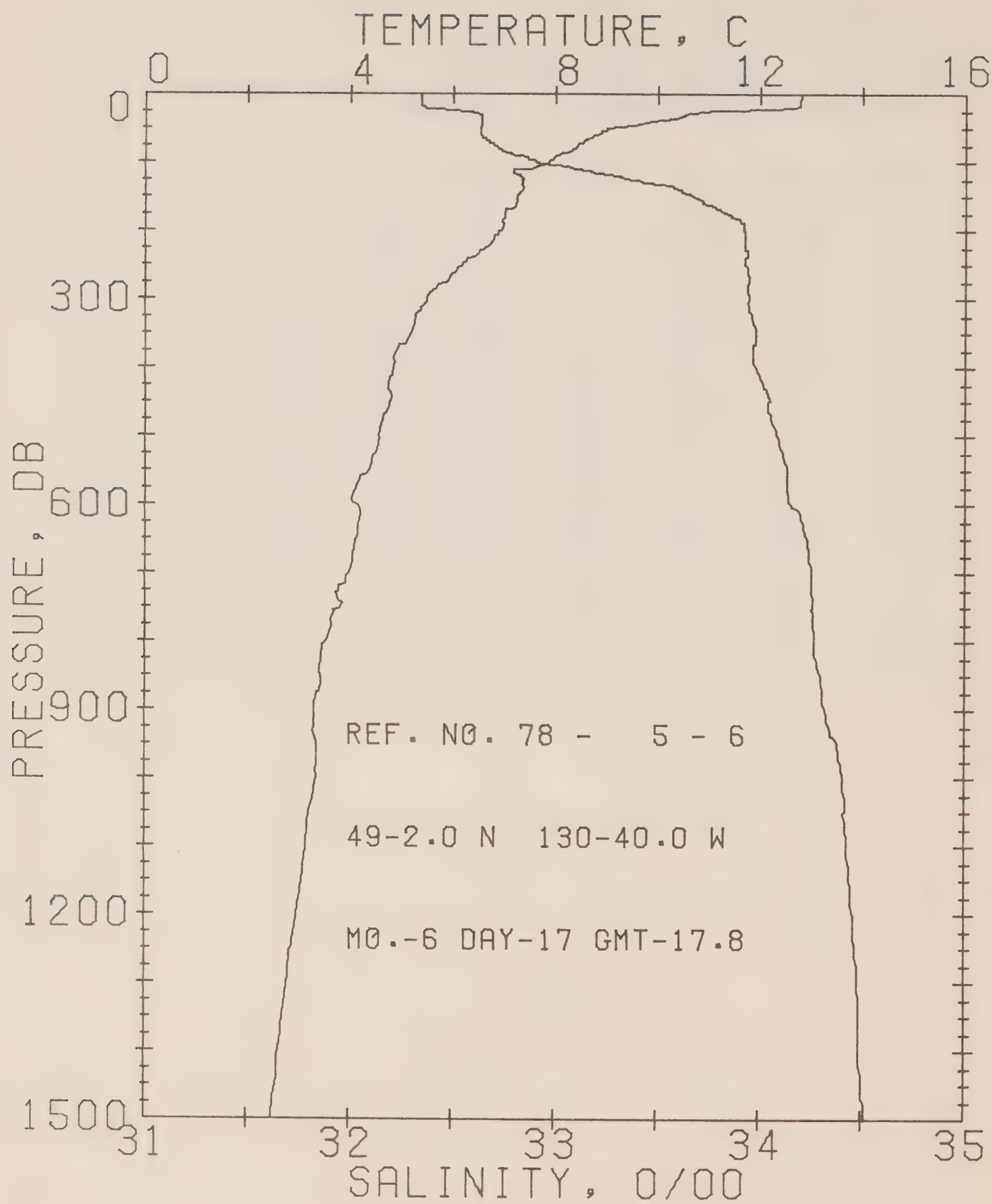
DATE 17/ 6/78

POSITION 48-51.0N, 128-40.0W GMT 11.3

RESULTS OF STP CAST 341 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 12.78 | 32.26 | 0 | 24.34 | 359.6 | .00 | .00 | 1497. |
| 10 | 12.76 | 32.26 | 10 | 24.34 | 359.6 | .36 | .02 | 1497. |
| 20 | 12.75 | 32.26 | 20 | 24.34 | 359.5 | .72 | .07 | 1497. |
| 30 | 10.47 | 32.38 | 30 | 24.85 | 311.4 | 1.05 | .16 | 1489. |
| 50 | 8.98 | 32.53 | 50 | 25.21 | 277.3 | 1.64 | .40 | 1484. |
| 75 | 8.14 | 32.81 | 75 | 25.56 | 244.8 | 2.30 | .81 | 1482. |
| 100 | 8.01 | 33.33 | 99 | 25.98 | 204.7 | 2.86 | 1.31 | 1482. |
| 125 | 7.92 | 33.63 | 124 | 26.23 | 181.4 | 3.34 | 1.86 | 1483. |
| 150 | 7.67 | 33.77 | 149 | 26.38 | 168.0 | 3.78 | 2.48 | 1482. |
| 175 | 7.37 | 33.88 | 174 | 26.51 | 156.1 | 4.18 | 3.14 | 1482. |
| 200 | 7.18 | 33.91 | 199 | 26.56 | 151.6 | 4.57 | 3.88 | 1482. |
| 225 | 6.95 | 33.93 | 223 | 26.61 | 147.4 | 4.94 | 4.69 | 1481. |
| 250 | 6.71 | 33.95 | 248 | 26.66 | 142.7 | 5.30 | 5.56 | 1481. |
| 300 | 6.32 | 33.98 | 298 | 26.73 | 136.4 | 6.00 | 7.51 | 1480. |
| 400 | 5.51 | 34.00 | 397 | 26.85 | 126.0 | 7.31 | 12.19 | 1478. |
| 500 | 4.91 | 34.03 | 496 | 26.94 | 117.6 | 8.52 | 17.75 | 1478. |
| 600 | 4.22 | 34.09 | 595 | 27.06 | 106.4 | 9.64 | 23.99 | 1476. |
| 800 | 3.83 | 34.27 | 793 | 27.25 | 90.0 | 11.59 | 37.84 | 1478. |
| 1000 | 3.41 | 34.38 | 991 | 27.37 | 78.8 | 13.27 | 53.24 | 1480. |
| 1200 | 3.02 | 34.43 | 1188 | 27.45 | 71.6 | 14.77 | 70.06 | 1482. |
| 1500 | 2.40 | 34.52 | 1484 | 27.58 | 60.0 | 16.73 | 96.90 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 6

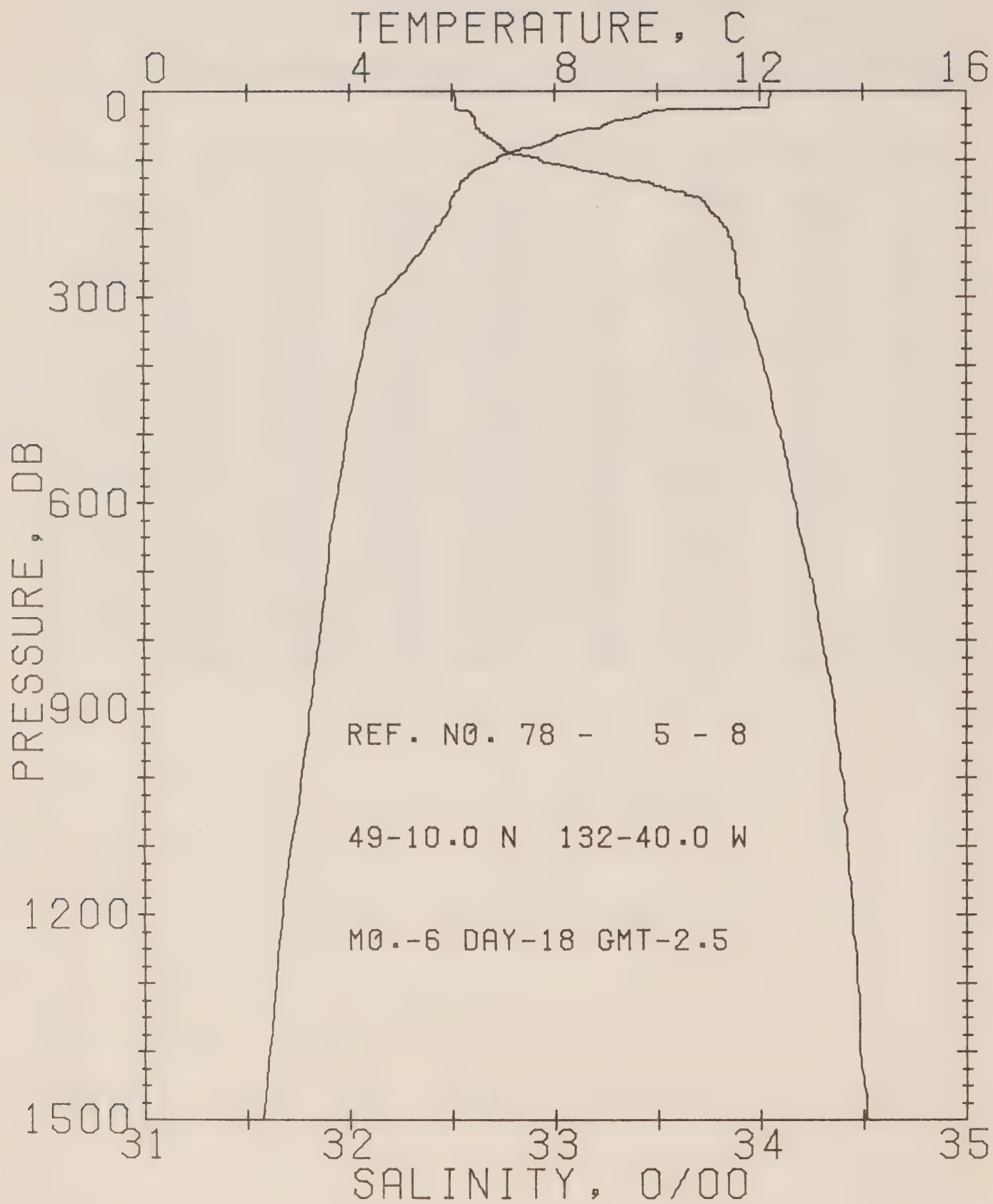
DATE 17/ 6/78

POSITION 49- 2.0N, 130-40.0W GMT 17.8

RESULTS OF STP CAST 385 POINTS TAKEN FROM ANALOG TRACE

BISETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 12.80 | 32.35 | 0 | 24.40 | 353.4 | .00 | .00 | 1497. |
| 10 | 12.78 | 32.35 | 10 | 24.41 | 353.2 | .35 | .02 | 1497. |
| 20 | 12.65 | 32.36 | 20 | 24.44 | 350.4 | .71 | .07 | 1497. |
| 30 | 10.55 | 32.63 | 30 | 25.03 | 294.3 | 1.02 | .15 | 1490. |
| 50 | 9.10 | 32.63 | 50 | 25.27 | 271.7 | 1.59 | .38 | 1485. |
| 75 | 8.44 | 32.70 | 75 | 25.43 | 257.3 | 2.25 | .80 | 1483. |
| 100 | 7.86 | 32.91 | 99 | 25.67 | 234.0 | 2.87 | 1.35 | 1481. |
| 125 | 7.40 | 33.36 | 124 | 26.09 | 194.7 | 3.40 | 1.96 | 1480. |
| 150 | 7.25 | 33.67 | 149 | 26.36 | 170.1 | 3.85 | 2.59 | 1481. |
| 175 | 7.01 | 33.83 | 174 | 26.52 | 154.9 | 4.25 | 3.26 | 1480. |
| 200 | 6.95 | 33.92 | 199 | 26.60 | 147.8 | 4.63 | 3.98 | 1481. |
| 225 | 6.65 | 33.93 | 223 | 26.65 | 143.4 | 4.99 | 4.76 | 1480. |
| 250 | 6.20 | 33.93 | 248 | 26.71 | 138.0 | 5.34 | 5.61 | 1479. |
| 300 | 5.50 | 33.95 | 298 | 26.81 | 128.5 | 6.01 | 7.47 | 1477. |
| 400 | 4.87 | 33.98 | 397 | 26.90 | 120.0 | 7.25 | 11.88 | 1476. |
| 500 | 4.57 | 34.08 | 496 | 27.02 | 110.0 | 8.40 | 17.15 | 1476. |
| 600 | 4.04 | 34.14 | 595 | 27.12 | 100.4 | 9.44 | 23.02 | 1476. |
| 800 | 3.58 | 34.27 | 793 | 27.27 | 87.2 | 11.31 | 36.26 | 1477. |
| 1000 | 3.34 | 34.40 | 991 | 27.40 | 76.2 | 12.94 | 51.19 | 1480. |
| 1200 | 2.98 | 34.45 | 1188 | 27.47 | 69.8 | 14.40 | 67.53 | 1481. |
| 1500 | 2.49 | 34.51 | 1484 | 27.56 | 61.6 | 16.36 | 94.50 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 8

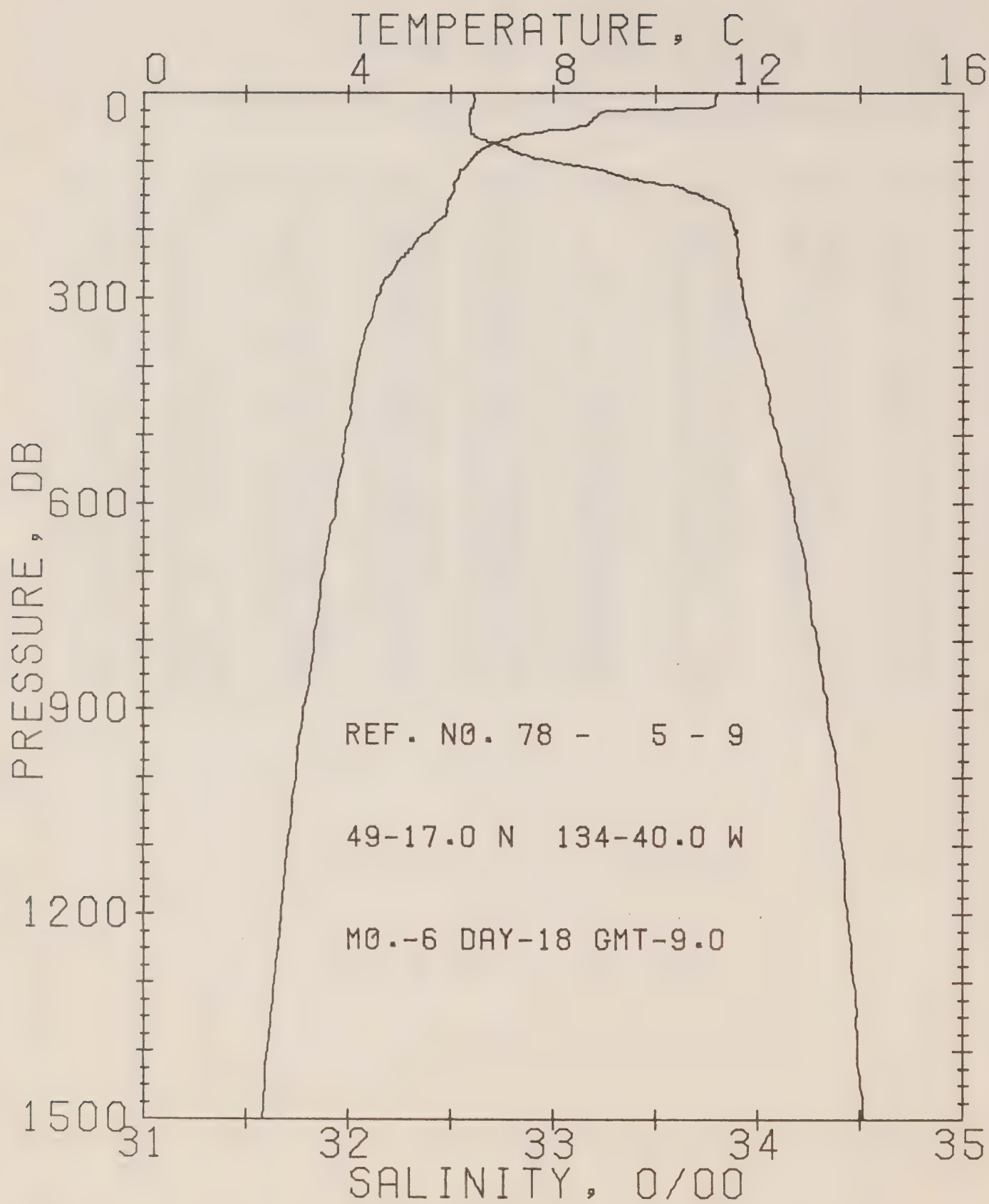
DATE 18/ 6/78

POSITION 49-10.0N, 132-40.0W GMT 2.5

RESULTS OF STP CAST 305 POINTS TAKEN FROM ANALOG TRACE

BISETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 12.21 | 32.51 | 0 | 24.64 | 330.8 | .00 | .00 | 1495. |
| 10 | 12.20 | 32.52 | 10 | 24.65 | 330.4 | .33 | .02 | 1495. |
| 20 | 12.20 | 32.52 | 20 | 24.65 | 330.4 | .66 | .07 | 1495. |
| 30 | 9.86 | 32.59 | 30 | 25.12 | 286.1 | .97 | .15 | 1487. |
| 50 | 8.95 | 32.62 | 50 | 25.29 | 270.2 | 1.53 | .37 | 1484. |
| 75 | 7.79 | 32.72 | 75 | 25.54 | 246.9 | 2.17 | .78 | 1480. |
| 100 | 6.87 | 32.93 | 99 | 25.83 | 219.0 | 2.76 | 1.30 | 1477. |
| 125 | 6.32 | 33.28 | 124 | 26.18 | 186.3 | 3.27 | 1.88 | 1476. |
| 150 | 6.05 | 33.64 | 149 | 26.50 | 156.4 | 3.69 | 2.48 | 1476. |
| 175 | 5.95 | 33.75 | 174 | 26.60 | 147.1 | 4.07 | 3.10 | 1476. |
| 200 | 5.69 | 33.83 | 199 | 26.69 | 138.5 | 4.42 | 3.78 | 1476. |
| 225 | 5.49 | 33.87 | 223 | 26.75 | 133.4 | 4.76 | 4.51 | 1475. |
| 250 | 5.22 | 33.88 | 248 | 26.79 | 129.8 | 5.09 | 5.31 | 1474. |
| 300 | 4.61 | 33.91 | 298 | 26.88 | 121.2 | 5.72 | 7.07 | 1473. |
| 400 | 4.22 | 34.01 | 397 | 27.00 | 110.1 | 6.87 | 11.16 | 1473. |
| 500 | 3.95 | 34.10 | 496 | 27.10 | 101.6 | 7.93 | 16.02 | 1474. |
| 600 | 3.74 | 34.16 | 595 | 27.17 | 95.4 | 8.92 | 21.55 | 1474. |
| 800 | 3.41 | 34.30 | 793 | 27.31 | 83.4 | 10.70 | 34.26 | 1477. |
| 1000 | 3.07 | 34.39 | 990 | 27.41 | 74.1 | 12.27 | 48.58 | 1478. |
| 1200 | 2.70 | 34.45 | 1188 | 27.50 | 66.8 | 13.67 | 64.32 | 1480. |
| 1500 | 2.32 | 34.51 | 1484 | 27.58 | 59.7 | 15.58 | 90.44 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 9

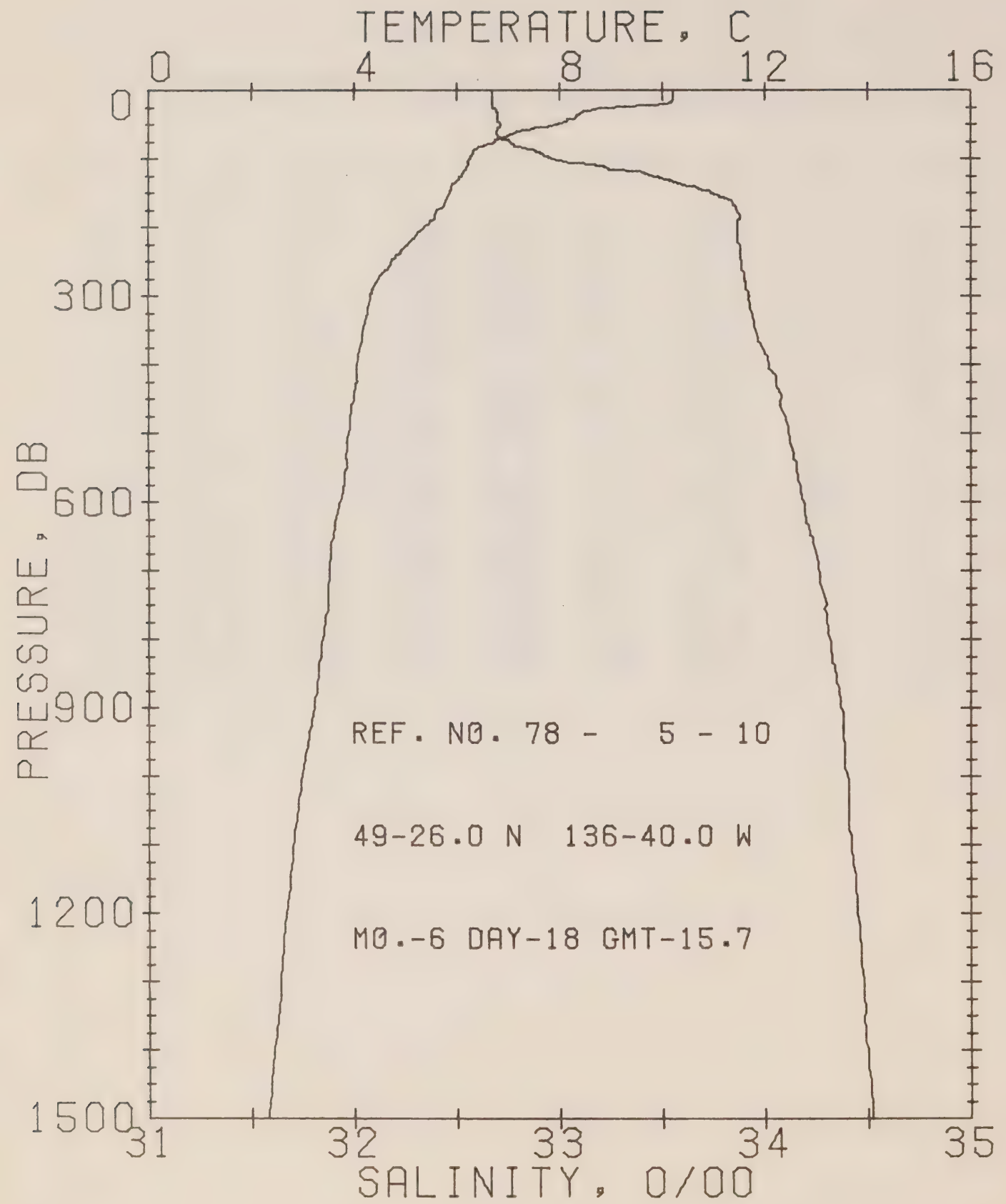
DATE 18/ 6/78

POSITION 49-17.0N, 134-40.0W GMT 9.0

RESULTS OF STP CAST 314 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 11.20 | 32.62 | 0 | 24.91 | 305.1 | .00 | .00 | 1492. |
| 10 | 11.18 | 32.62 | 10 | 24.91 | 305.0 | .31 | .02 | 1492. |
| 20 | 11.09 | 32.61 | 20 | 24.92 | 304.4 | .61 | .06 | 1492. |
| 30 | 8.91 | 32.60 | 30 | 25.28 | 270.6 | .89 | .13 | 1484. |
| 50 | 8.49 | 32.60 | 50 | 25.34 | 265.1 | 1.43 | .35 | 1482. |
| 75 | 6.78 | 32.72 | 75 | 25.68 | 233.0 | 2.05 | .75 | 1476. |
| 100 | 6.38 | 32.99 | 99 | 25.94 | 208.4 | 2.61 | 1.24 | 1476. |
| 125 | 6.15 | 33.36 | 124 | 26.26 | 178.0 | 3.09 | 1.79 | 1476. |
| 150 | 6.01 | 33.72 | 149 | 26.56 | 150.2 | 3.49 | 2.35 | 1476. |
| 175 | 5.92 | 33.86 | 174 | 26.68 | 138.8 | 3.85 | 2.95 | 1476. |
| 200 | 5.62 | 33.89 | 199 | 26.75 | 133.2 | 4.19 | 3.60 | 1475. |
| 225 | 5.27 | 33.90 | 223 | 26.80 | 128.6 | 4.52 | 4.30 | 1474. |
| 250 | 4.96 | 33.90 | 248 | 26.83 | 125.3 | 4.83 | 5.07 | 1473. |
| 300 | 4.56 | 33.93 | 298 | 26.90 | 119.1 | 5.44 | 6.78 | 1473. |
| 400 | 4.19 | 34.02 | 397 | 27.01 | 109.3 | 6.59 | 10.85 | 1473. |
| 500 | 3.96 | 34.09 | 496 | 27.09 | 102.2 | 7.65 | 15.71 | 1474. |
| 600 | 3.77 | 34.17 | 595 | 27.17 | 95.2 | 8.64 | 21.25 | 1475. |
| 800 | 3.34 | 34.29 | 793 | 27.31 | 83.1 | 10.42 | 33.94 | 1476. |
| 1000 | 2.99 | 34.39 | 990 | 27.42 | 73.2 | 11.99 | 48.28 | 1478. |
| 1200 | 2.71 | 34.44 | 1188 | 27.48 | 67.9 | 13.40 | 64.07 | 1480. |
| 1500 | 2.34 | 34.51 | 1484 | 27.57 | 59.9 | 15.30 | 90.21 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 10

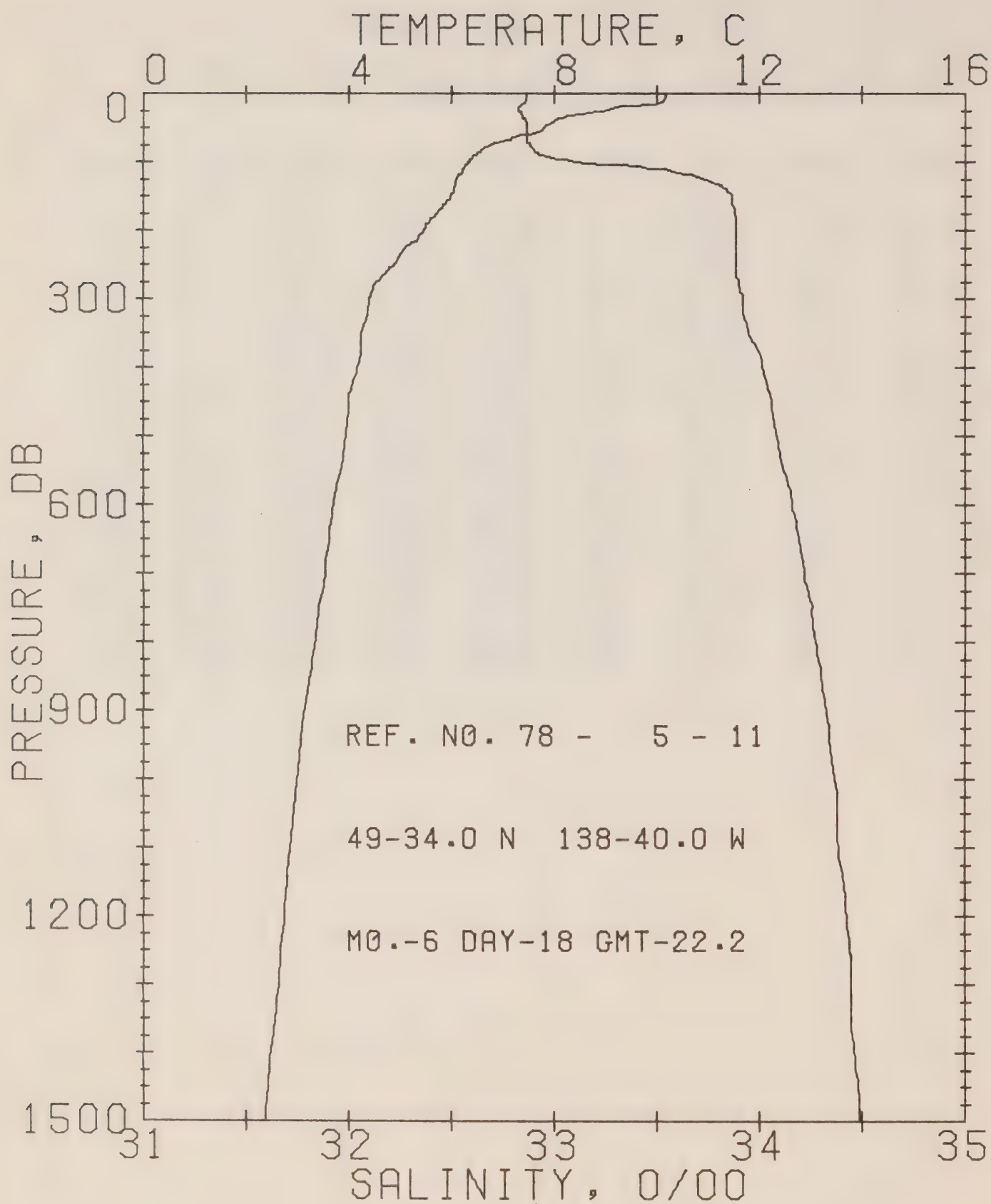
DATE 18/ 6/78

POSITION 49-26.0N, 136-40.0W GMT 15.7

RESULTS OF STP CAST 359 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 10.21 | 32.67 | 0 | 25.12 | 285.0 | .00 | .00 | 1488. |
| 10 | 10.21 | 32.67 | 10 | 25.12 | 285.2 | .29 | .01 | 1488. |
| 20 | 10.06 | 32.67 | 20 | 25.15 | 283.0 | .57 | .06 | 1488. |
| 30 | 8.57 | 32.69 | 30 | 25.40 | 259.0 | .84 | .13 | 1483. |
| 50 | 7.96 | 32.71 | 50 | 25.51 | 249.2 | 1.35 | .33 | 1481. |
| 75 | 6.74 | 32.75 | 75 | 25.71 | 230.2 | 1.95 | .71 | 1476. |
| 100 | 6.26 | 32.96 | 99 | 25.94 | 208.8 | 2.49 | 1.20 | 1475. |
| 125 | 6.12 | 33.45 | 124 | 26.34 | 171.2 | 2.97 | 1.74 | 1476. |
| 150 | 5.87 | 33.73 | 149 | 26.59 | 147.5 | 3.36 | 2.30 | 1475. |
| 175 | 5.64 | 33.86 | 174 | 26.72 | 135.3 | 3.71 | 2.88 | 1475. |
| 200 | 5.39 | 33.87 | 199 | 26.76 | 131.9 | 4.05 | 3.51 | 1474. |
| 225 | 5.06 | 33.87 | 223 | 26.80 | 128.0 | 4.37 | 4.22 | 1473. |
| 250 | 4.74 | 33.89 | 248 | 26.85 | 123.6 | 4.69 | 4.98 | 1473. |
| 300 | 4.33 | 33.92 | 298 | 26.92 | 117.4 | 5.29 | 6.66 | 1472. |
| 400 | 4.06 | 34.01 | 397 | 27.02 | 108.3 | 6.42 | 10.70 | 1472. |
| 500 | 3.90 | 34.11 | 496 | 27.11 | 100.3 | 7.46 | 15.46 | 1473. |
| 600 | 3.75 | 34.18 | 595 | 27.18 | 94.1 | 8.43 | 20.91 | 1475. |
| 800 | 3.40 | 34.31 | 793 | 27.32 | 82.2 | 10.18 | 33.33 | 1476. |
| 1000 | 3.00 | 34.39 | 990 | 27.42 | 73.0 | 11.72 | 47.45 | 1478. |
| 1200 | 2.69 | 34.45 | 1188 | 27.50 | 66.7 | 13.12 | 63.09 | 1480. |
| 1500 | 2.34 | 34.52 | 1484 | 27.58 | 59.1 | 15.01 | 89.05 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 11

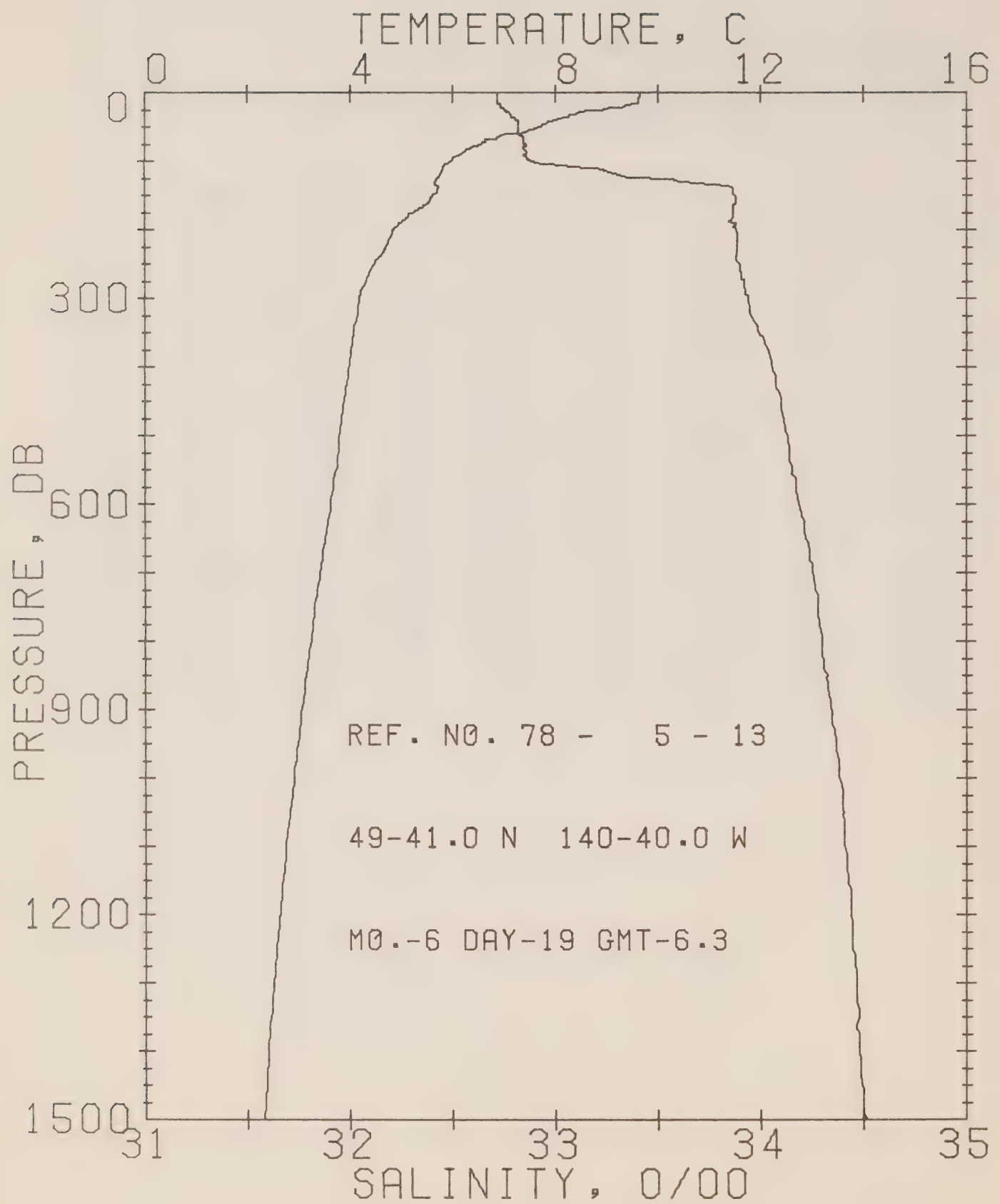
DATE 18/ 6/78

POSITION 49-34.0N, 138-40.0W GMT 22.2

RESULTS OF STP CAST 262 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 10.17 | 32.87 | 0 | 25.28 | 269.6 | .00 | .00 | 1488. |
| 10 | 10.13 | 32.87 | 10 | 25.29 | 269.2 | .27 | .01 | 1488. |
| 20 | 9.19 | 32.83 | 20 | 25.41 | 257.6 | .54 | .05 | 1485. |
| 30 | 8.62 | 32.84 | 30 | 25.51 | 248.7 | .79 | .12 | 1483. |
| 50 | 7.78 | 32.87 | 50 | 25.66 | 234.9 | 1.27 | .31 | 1480. |
| 75 | 6.76 | 32.88 | 75 | 25.81 | 221.0 | 1.84 | .68 | 1477. |
| 100 | 6.34 | 33.11 | 99 | 26.04 | 199.0 | 2.37 | 1.15 | 1476. |
| 125 | 6.10 | 33.72 | 124 | 26.55 | 150.6 | 2.80 | 1.63 | 1476. |
| 150 | 6.00 | 33.87 | 149 | 26.68 | 138.7 | 3.15 | 2.14 | 1476. |
| 175 | 5.73 | 33.88 | 174 | 26.72 | 135.0 | 3.50 | 2.70 | 1475. |
| 200 | 5.46 | 33.89 | 199 | 26.76 | 131.3 | 3.83 | 3.34 | 1475. |
| 225 | 5.14 | 33.89 | 223 | 26.80 | 127.9 | 4.15 | 4.04 | 1474. |
| 250 | 4.91 | 33.89 | 248 | 26.83 | 125.5 | 4.47 | 4.81 | 1473. |
| 300 | 4.41 | 33.92 | 298 | 26.91 | 118.2 | 5.08 | 6.51 | 1472. |
| 400 | 4.18 | 34.01 | 397 | 27.00 | 109.9 | 6.22 | 10.59 | 1473. |
| 500 | 3.96 | 34.08 | 496 | 27.08 | 103.0 | 7.28 | 15.44 | 1474. |
| 600 | 3.72 | 34.16 | 595 | 27.17 | 95.5 | 8.28 | 21.01 | 1474. |
| 800 | 3.36 | 34.27 | 793 | 27.29 | 84.7 | 10.08 | 33.81 | 1476. |
| 1000 | 3.01 | 34.36 | 990 | 27.40 | 75.5 | 11.67 | 48.40 | 1478. |
| 1200 | 2.76 | 34.42 | 1188 | 27.47 | 69.5 | 13.12 | 64.63 | 1480. |
| 1500 | 2.38 | 34.49 | 1484 | 27.55 | 61.8 | 15.09 | 91.71 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 13

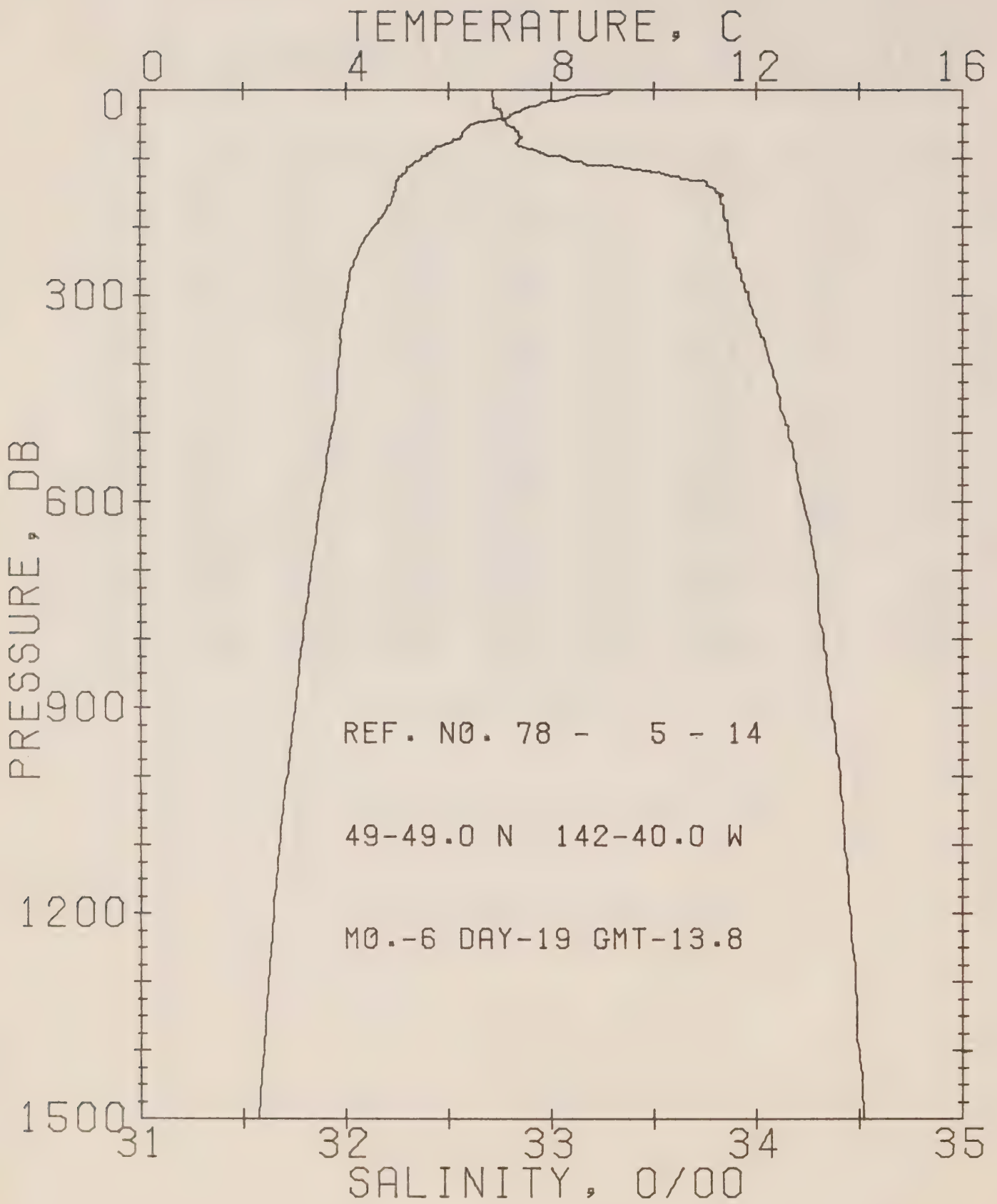
DATE 19/ 6/78

POSITION 49-41.0N, 140-40.0W GMT 6.3

RESULTS OF STP CAST 354 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 9.66 | 32.72 | 0 | 25.25 | 272.6 | .00 | .00 | 1486. |
| 10 | 9.64 | 32.72 | 10 | 25.26 | 272.5 | .27 | .01 | 1486. |
| 20 | 9.37 | 32.73 | 20 | 25.31 | 267.8 | .54 | .06 | 1485. |
| 30 | 8.46 | 32.77 | 30 | 25.48 | 251.2 | .80 | .12 | 1482. |
| 50 | 7.68 | 32.82 | 50 | 25.63 | 237.2 | 1.29 | .32 | 1480. |
| 75 | 6.54 | 32.85 | 75 | 25.81 | 220.3 | 1.86 | .68 | 1476. |
| 100 | 5.97 | 32.88 | 99 | 25.91 | 211.3 | 2.40 | 1.16 | 1474. |
| 125 | 5.70 | 33.42 | 124 | 26.36 | 168.6 | 2.87 | 1.70 | 1474. |
| 150 | 5.62 | 33.87 | 149 | 26.73 | 134.1 | 3.23 | 2.20 | 1474. |
| 175 | 5.25 | 33.87 | 174 | 26.77 | 130.0 | 3.56 | 2.75 | 1473. |
| 200 | 4.86 | 33.88 | 199 | 26.83 | 125.3 | 3.88 | 3.36 | 1472. |
| 225 | 4.72 | 33.89 | 223 | 26.85 | 123.1 | 4.19 | 4.03 | 1472. |
| 250 | 4.49 | 33.90 | 248 | 26.88 | 120.5 | 4.50 | 4.77 | 1472. |
| 300 | 4.20 | 33.94 | 298 | 26.95 | 114.5 | 5.08 | 6.42 | 1471. |
| 400 | 3.99 | 34.05 | 397 | 27.06 | 104.7 | 6.18 | 10.32 | 1472. |
| 500 | 3.81 | 34.12 | 496 | 27.13 | 98.2 | 7.19 | 14.96 | 1473. |
| 600 | 3.64 | 34.18 | 595 | 27.20 | 92.9 | 8.15 | 20.32 | 1474. |
| 800 | 3.25 | 34.30 | 793 | 27.32 | 81.5 | 9.88 | 32.63 | 1470. |
| 1000 | 2.92 | 34.38 | 990 | 27.42 | 73.2 | 11.42 | 46.77 | 1470. |
| 1200 | 2.64 | 34.44 | 1188 | 27.49 | 66.9 | 12.82 | 62.39 | 1480. |
| 1500 | 2.34 | 34.50 | 1484 | 27.57 | 60.6 | 14.72 | 88.52 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 14

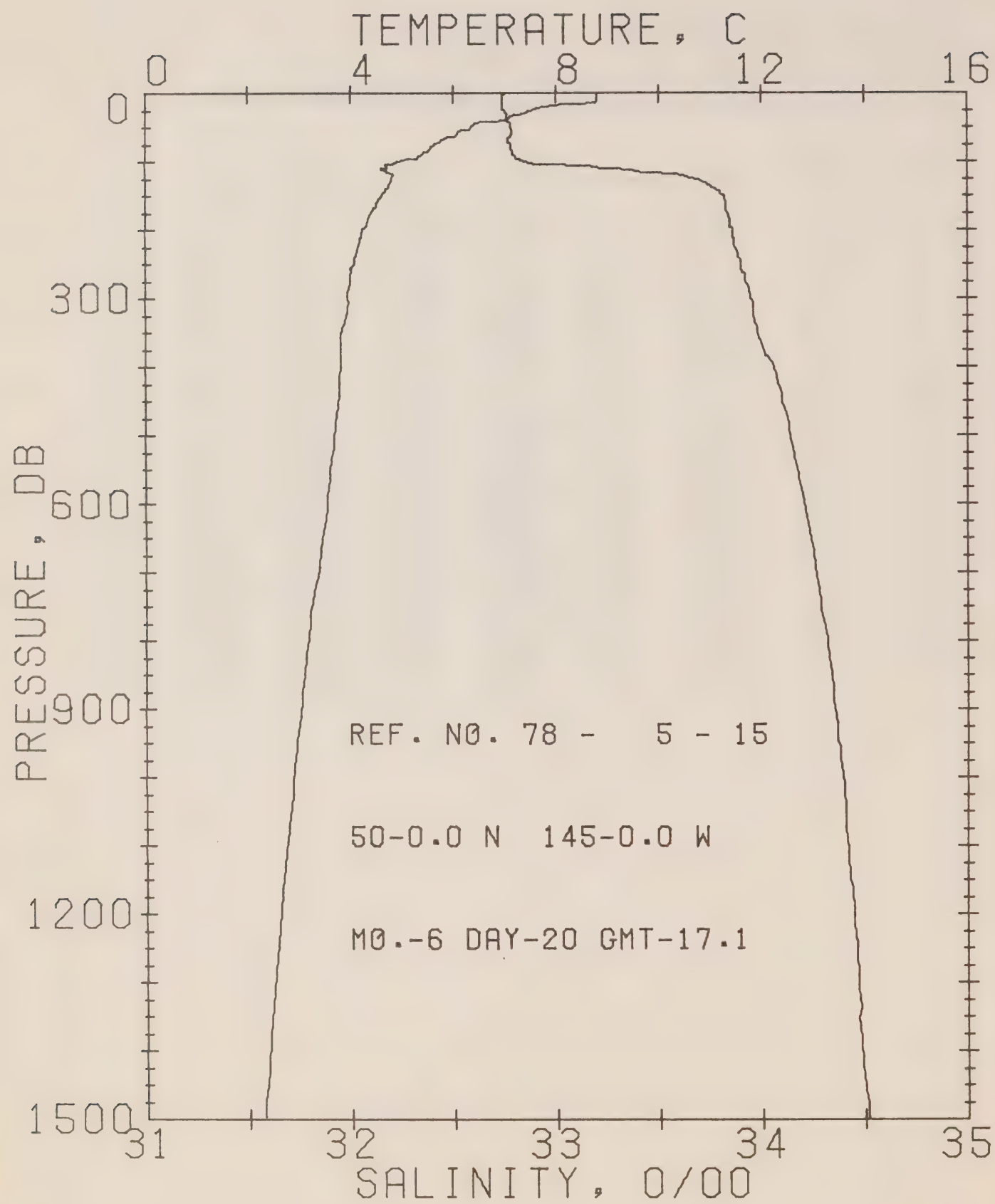
DATE 19/ 6/78

POSITION 49-49.0N, 142-40.0W GMT 13.8

RESULTS OF STP CAST 330 POINTS TAKEN FROM ANALOG TRACE

BISETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 9.19 | 32.71 | 0 | 25.32 | 266.2 | .00 | .00 | 1484. |
| 10 | 8.41 | 32.71 | 10 | 25.44 | 255.0 | .26 | .01 | 1482. |
| 20 | 7.78 | 32.72 | 20 | 25.54 | 245.6 | .51 | .05 | 1479. |
| 30 | 7.43 | 32.75 | 30 | 25.61 | 238.7 | .76 | .11 | 1478. |
| 50 | 6.47 | 32.78 | 50 | 25.76 | 224.5 | 1.22 | .30 | 1475. |
| 75 | 6.09 | 32.84 | 75 | 25.86 | 215.7 | 1.77 | .65 | 1474. |
| 100 | 5.47 | 33.07 | 99 | 26.12 | 191.3 | 2.28 | 1.11 | 1472. |
| 125 | 5.09 | 33.57 | 124 | 26.55 | 150.5 | 2.71 | 1.60 | 1472. |
| 150 | 4.93 | 33.81 | 149 | 26.76 | 130.7 | 3.06 | 2.08 | 1472. |
| 175 | 4.79 | 33.84 | 174 | 26.80 | 127.2 | 3.38 | 2.61 | 1471. |
| 200 | 4.57 | 33.86 | 199 | 26.84 | 123.5 | 3.69 | 3.21 | 1471. |
| 225 | 4.34 | 33.87 | 223 | 26.88 | 120.2 | 4.00 | 3.87 | 1470. |
| 250 | 4.18 | 33.90 | 248 | 26.92 | 116.9 | 4.29 | 4.59 | 1470. |
| 300 | 4.03 | 33.96 | 298 | 26.98 | 111.2 | 4.86 | 6.18 | 1470. |
| 400 | 3.87 | 34.06 | 397 | 27.08 | 102.6 | 5.93 | 9.99 | 1472. |
| 500 | 3.72 | 34.15 | 496 | 27.16 | 95.4 | 6.92 | 14.54 | 1473. |
| 600 | 3.52 | 34.22 | 595 | 27.24 | 88.7 | 7.84 | 19.69 | 1474. |
| 800 | 3.16 | 34.33 | 793 | 27.35 | 78.5 | 9.50 | 31.50 | 1475. |
| 1000 | 2.88 | 34.41 | 990 | 27.44 | 70.8 | 11.00 | 45.21 | 1478. |
| 1200 | 2.60 | 34.45 | 1188 | 27.51 | 65.5 | 12.36 | 60.42 | 1480. |
| 1500 | 2.31 | 34.52 | 1484 | 27.58 | 58.8 | 14.22 | 86.01 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 15

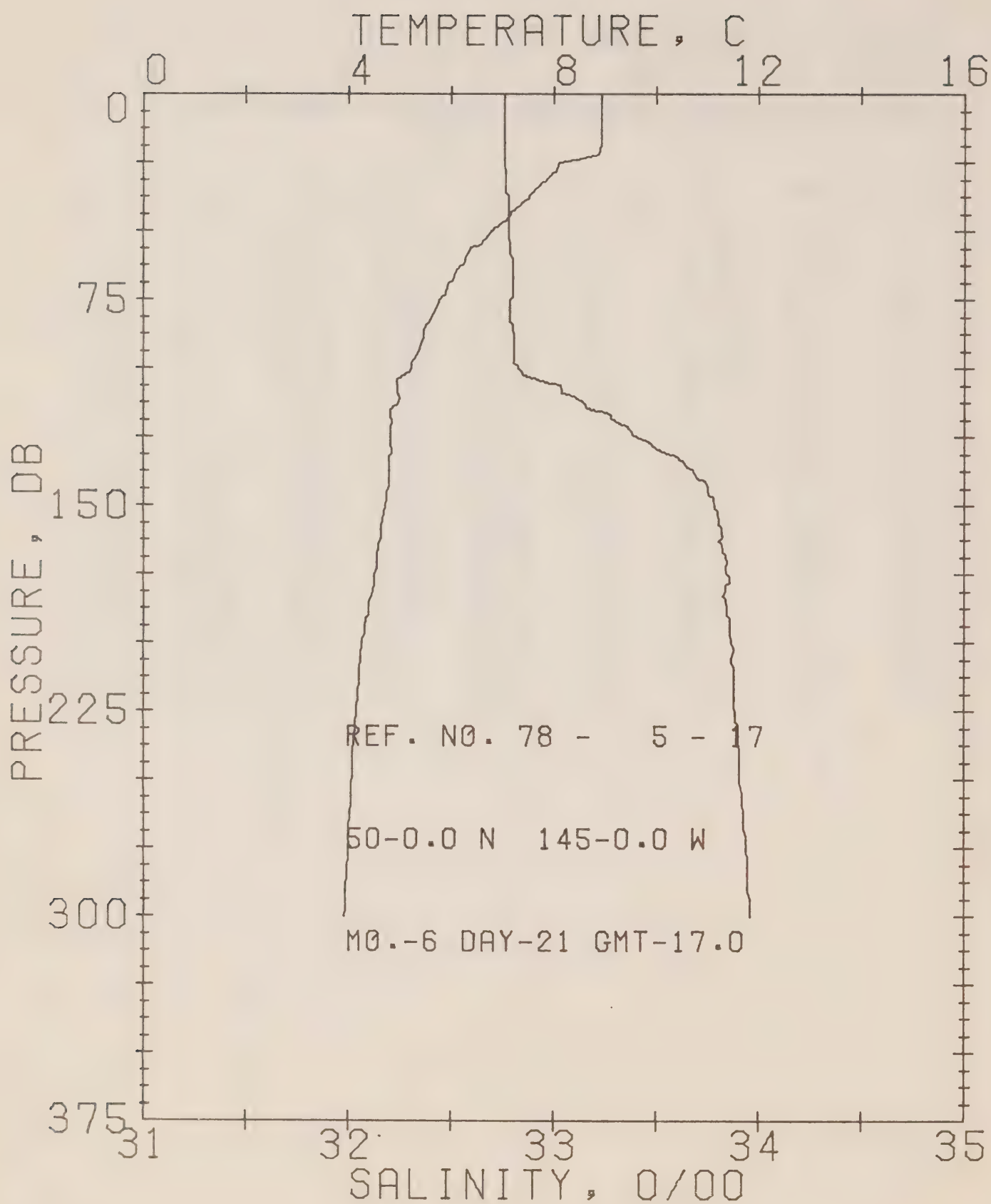
DATE 20/ 6/78

POSITION 50- .0N, 145- .0W GMT 17.1

RESULTS OF STP CAST 232 POINTS TAKEN FROM ANALOG TRACE

BISETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 8.81 | 32.75 | 0 | 25.41 | 257.6 | .00 | .00 | 1483. |
| 10 | 8.79 | 32.74 | 10 | 25.41 | 258.2 | .26 | .01 | 1483. |
| 20 | 7.76 | 32.74 | 20 | 25.56 | 243.7 | .51 | .05 | 1479. |
| 30 | 7.38 | 32.76 | 30 | 25.63 | 237.6 | .75 | .11 | 1478. |
| 50 | 6.34 | 32.78 | 50 | 25.78 | 222.9 | 1.21 | .30 | 1474. |
| 75 | 5.65 | 32.78 | 75 | 25.87 | 215.0 | 1.76 | .65 | 1472. |
| 100 | 4.92 | 32.84 | 99 | 26.00 | 202.4 | 2.29 | 1.12 | 1469. |
| 125 | 4.81 | 33.66 | 124 | 26.66 | 140.6 | 2.71 | 1.60 | 1470. |
| 150 | 4.62 | 33.82 | 149 | 26.80 | 126.8 | 3.04 | 2.06 | 1470. |
| 175 | 4.42 | 33.83 | 174 | 26.84 | 123.7 | 3.35 | 2.58 | 1470. |
| 200 | 4.26 | 33.86 | 199 | 26.88 | 120.3 | 3.65 | 3.16 | 1470. |
| 225 | 4.17 | 33.87 | 223 | 26.89 | 118.7 | 3.95 | 3.81 | 1470. |
| 250 | 4.08 | 33.90 | 248 | 26.93 | 115.7 | 4.25 | 4.51 | 1470. |
| 300 | 3.96 | 33.95 | 298 | 26.98 | 111.2 | 4.81 | 6.10 | 1470. |
| 400 | 3.81 | 34.05 | 397 | 27.08 | 102.7 | 5.89 | 9.94 | 1471. |
| 500 | 3.70 | 34.14 | 496 | 27.15 | 96.3 | 6.88 | 14.49 | 1473. |
| 600 | 3.55 | 34.20 | 595 | 27.22 | 90.4 | 7.82 | 19.72 | 1474. |
| 800 | 3.17 | 34.32 | 793 | 27.35 | 79.3 | 9.51 | 31.78 | 1475. |
| 1000 | 2.88 | 34.39 | 990 | 27.43 | 71.9 | 11.02 | 45.62 | 1478. |
| 1200 | 2.62 | 34.45 | 1188 | 27.50 | 66.2 | 12.41 | 61.12 | 1480. |
| 1500 | 2.29 | 34.51 | 1484 | 27.58 | 59.3 | 14.30 | 87.08 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 17

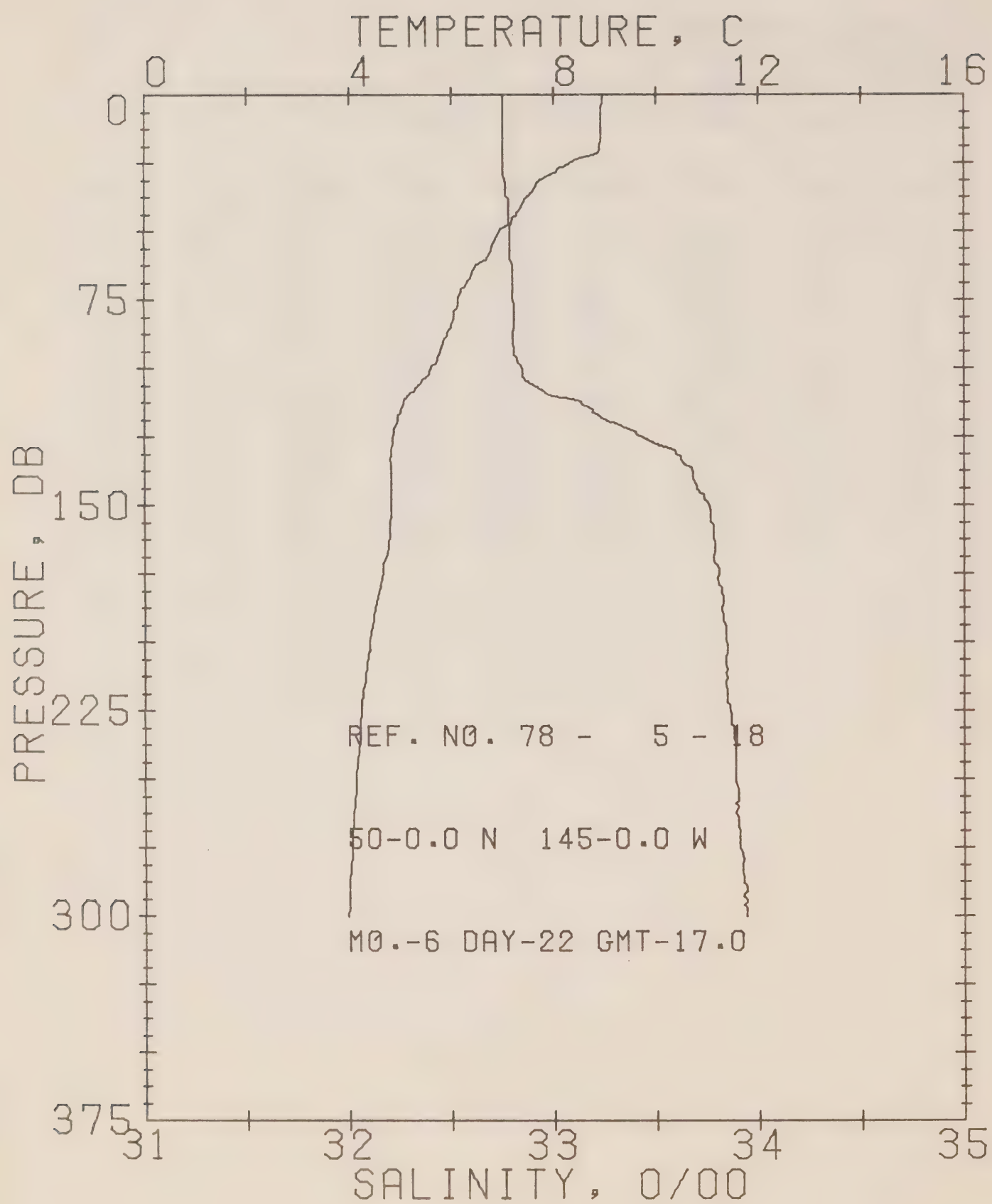
DATE 21/ 6/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 204 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 8.94 | 32.76 | 0 | 25.40 | 258.8 | .00 | .00 | 1484. |
| 10 | 8.94 | 32.76 | 10 | 25.40 | 258.9 | .26 | .01 | 1484. |
| 20 | 8.92 | 32.76 | 20 | 25.40 | 258.8 | .52 | .05 | 1484. |
| 30 | 7.93 | 32.77 | 30 | 25.56 | 244.0 | .77 | .12 | 1480. |
| 50 | 6.79 | 32.78 | 50 | 25.72 | 228.5 | 1.24 | .31 | 1476. |
| 75 | 5.79 | 32.79 | 75 | 25.86 | 215.5 | 1.79 | .66 | 1473. |
| 100 | 5.23 | 32.83 | 99 | 25.96 | 206.8 | 2.32 | 1.13 | 1471. |
| 125 | 4.82 | 33.39 | 124 | 26.45 | 160.4 | 2.78 | 1.65 | 1470. |
| 150 | 4.74 | 33.78 | 149 | 26.76 | 130.5 | 3.13 | 2.15 | 1471. |
| 175 | 4.53 | 33.84 | 174 | 26.83 | 124.4 | 3.45 | 2.67 | 1470. |
| 200 | 4.29 | 33.87 | 199 | 26.88 | 119.9 | 3.75 | 3.26 | 1470. |
| 225 | 4.17 | 33.88 | 223 | 26.90 | 117.9 | 4.05 | 3.90 | 1470. |
| 250 | 4.08 | 33.91 | 248 | 26.93 | 115.0 | 4.34 | 4.60 | 1470. |
| 300 | 3.94 | 33.96 | 298 | 26.99 | 110.3 | 4.90 | 6.17 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 18

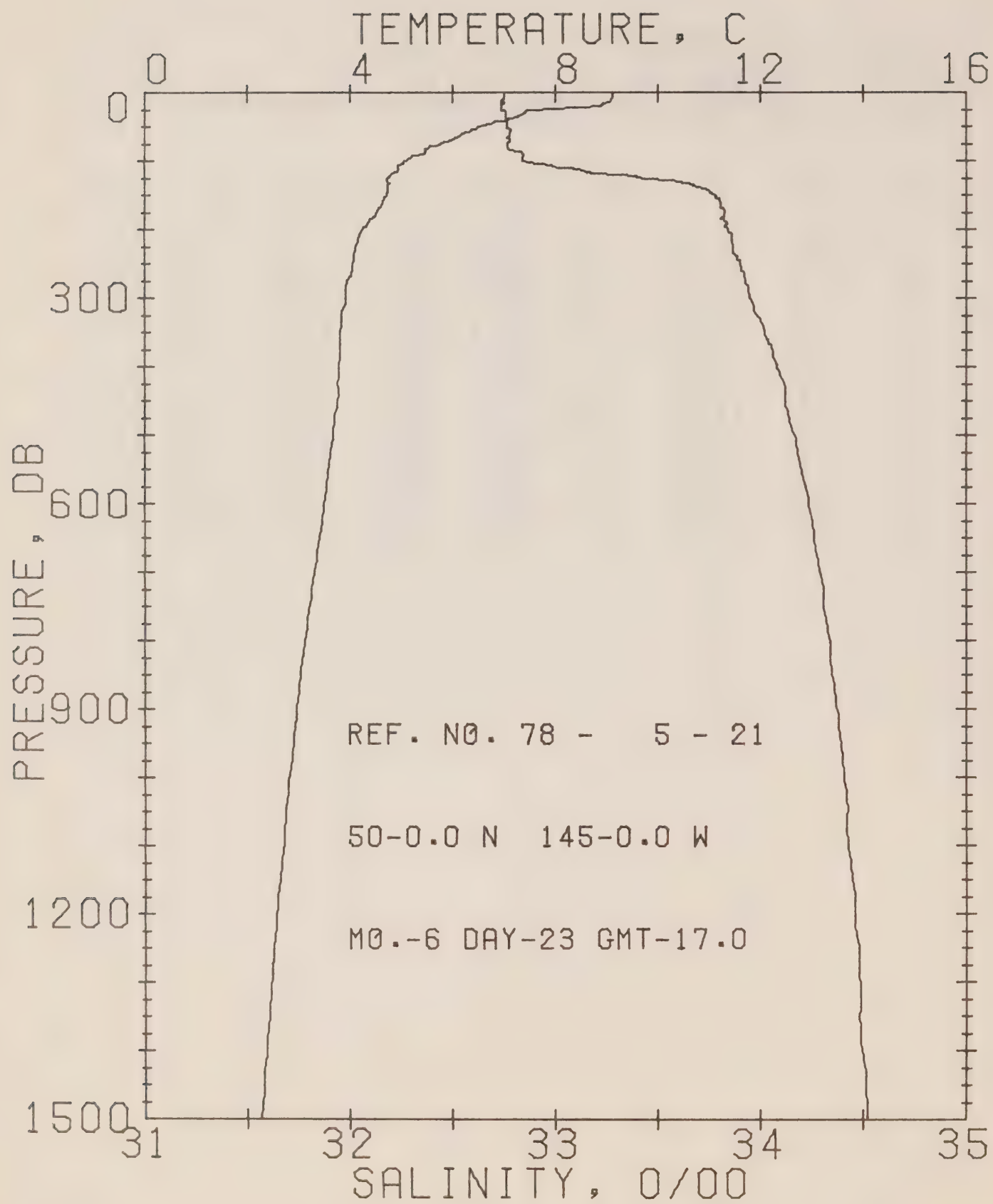
DATE 22/ 6/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 228 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 8.95 | 32.75 | 0 | 25.39 | 259.6 | .00 | .00 | 1484. |
| 10 | 8.94 | 32.75 | 10 | 25.39 | 259.7 | .26 | .01 | 1484. |
| 20 | 8.90 | 32.75 | 20 | 25.40 | 259.3 | .52 | .05 | 1484. |
| 30 | 7.86 | 32.75 | 30 | 25.56 | 244.3 | .77 | .12 | 1480. |
| 50 | 6.94 | 32.79 | 50 | 25.71 | 229.7 | 1.24 | .31 | 1477. |
| 75 | 6.14 | 32.80 | 75 | 25.82 | 219.1 | 1.81 | .67 | 1474. |
| 100 | 5.61 | 32.84 | 99 | 25.92 | 210.1 | 2.35 | 1.15 | 1472. |
| 125 | 4.87 | 33.42 | 124 | 26.46 | 159.3 | 2.81 | 1.68 | 1470. |
| 150 | 4.83 | 33.75 | 149 | 26.73 | 134.1 | 3.17 | 2.18 | 1471. |
| 175 | 4.67 | 33.81 | 174 | 26.79 | 128.1 | 3.50 | 2.72 | 1471. |
| 200 | 4.41 | 33.84 | 199 | 26.84 | 123.2 | 3.81 | 3.32 | 1470. |
| 225 | 4.23 | 33.86 | 223 | 26.88 | 120.1 | 4.12 | 3.98 | 1470. |
| 250 | 4.14 | 33.89 | 248 | 26.91 | 117.1 | 4.41 | 4.70 | 1470. |
| 300 | 3.99 | 33.94 | 298 | 26.97 | 112.3 | 4.99 | 6.31 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 21

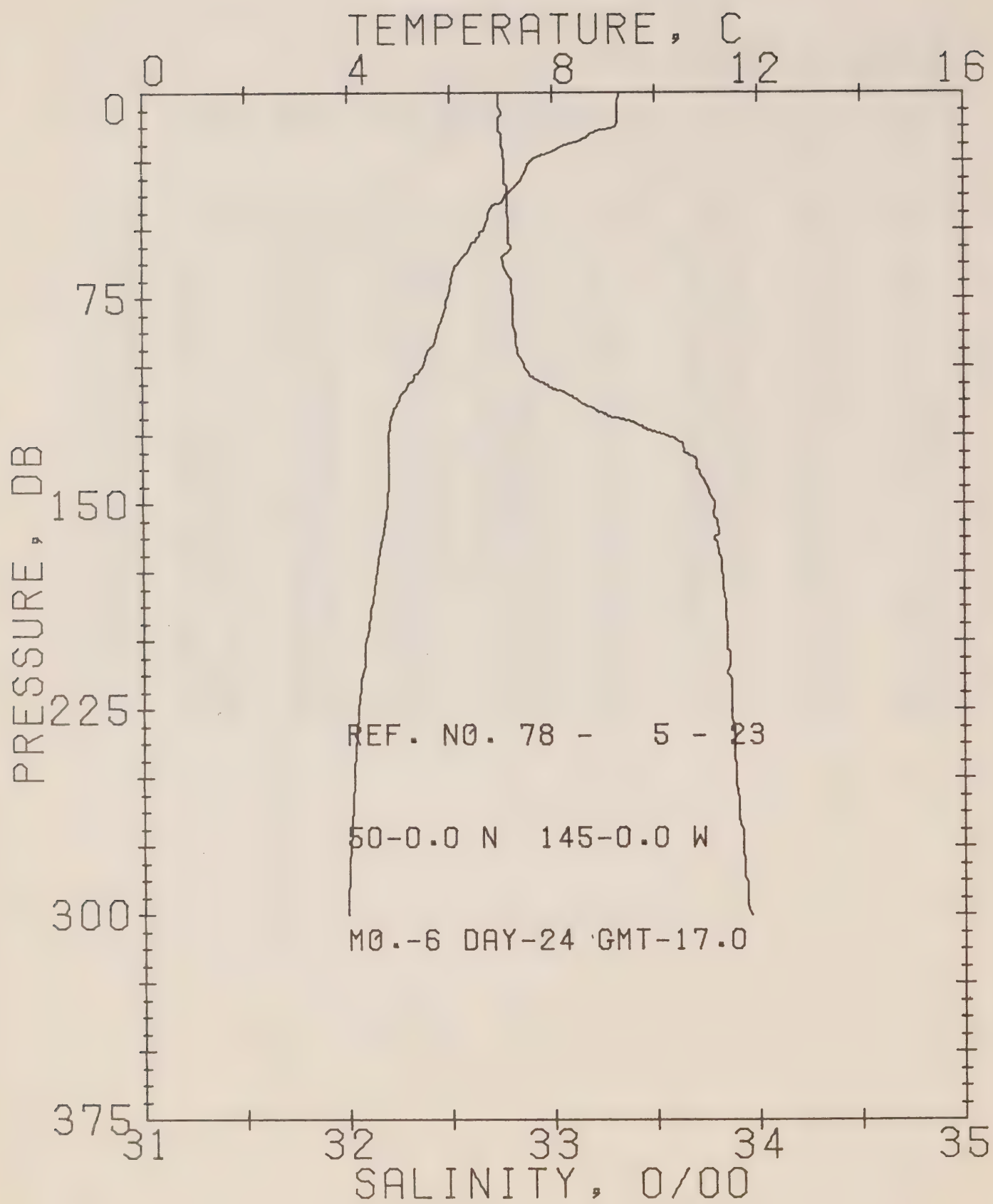
DATE 23/ 6/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 318 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 9.13 | 32.75 | 0 | 25.36 | 262.3 | .00 | .00 | 1484. |
| 10 | 9.10 | 32.75 | 10 | 25.37 | 262.1 | .26 | .01 | 1484. |
| 20 | 8.90 | 32.74 | 20 | 25.39 | 260.0 | .52 | .05 | 1484. |
| 30 | 7.41 | 32.76 | 30 | 25.62 | 237.8 | .77 | .12 | 1478. |
| 50 | 6.56 | 32.77 | 50 | 25.75 | 226.3 | 1.23 | .30 | 1475. |
| 75 | 5.77 | 32.77 | 75 | 25.84 | 217.2 | 1.79 | .66 | 1472. |
| 100 | 5.07 | 32.85 | 99 | 25.98 | 204.0 | 2.31 | 1.12 | 1470. |
| 125 | 4.75 | 33.41 | 124 | 26.46 | 158.8 | 2.77 | 1.65 | 1470. |
| 150 | 4.71 | 33.77 | 149 | 26.76 | 131.3 | 3.12 | 2.14 | 1471. |
| 175 | 4.53 | 33.83 | 174 | 26.82 | 125.1 | 3.44 | 2.67 | 1470. |
| 200 | 4.25 | 33.84 | 199 | 26.86 | 121.6 | 3.75 | 3.26 | 1470. |
| 225 | 4.12 | 33.87 | 223 | 26.90 | 118.2 | 4.05 | 3.90 | 1469. |
| 250 | 4.06 | 33.90 | 248 | 26.93 | 115.6 | 4.34 | 4.61 | 1470. |
| 300 | 3.92 | 33.95 | 298 | 26.98 | 110.8 | 4.91 | 6.20 | 1470. |
| 400 | 3.80 | 34.08 | 397 | 27.10 | 100.7 | 5.96 | 9.95 | 1471. |
| 500 | 3.68 | 34.16 | 496 | 27.17 | 94.6 | 6.94 | 14.42 | 1473. |
| 600 | 3.51 | 34.23 | 595 | 27.25 | 88.0 | 7.85 | 19.53 | 1474. |
| 800 | 3.14 | 34.33 | 793 | 27.36 | 77.8 | 9.50 | 31.28 | 1475. |
| 1000 | 2.84 | 34.41 | 990 | 27.45 | 70.2 | 10.98 | 44.84 | 1478. |
| 1200 | 2.58 | 34.46 | 1188 | 27.51 | 64.8 | 12.33 | 59.99 | 1480. |
| 1500 | 2.29 | 34.52 | 1483 | 27.59 | 58.6 | 14.19 | 85.43 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 23

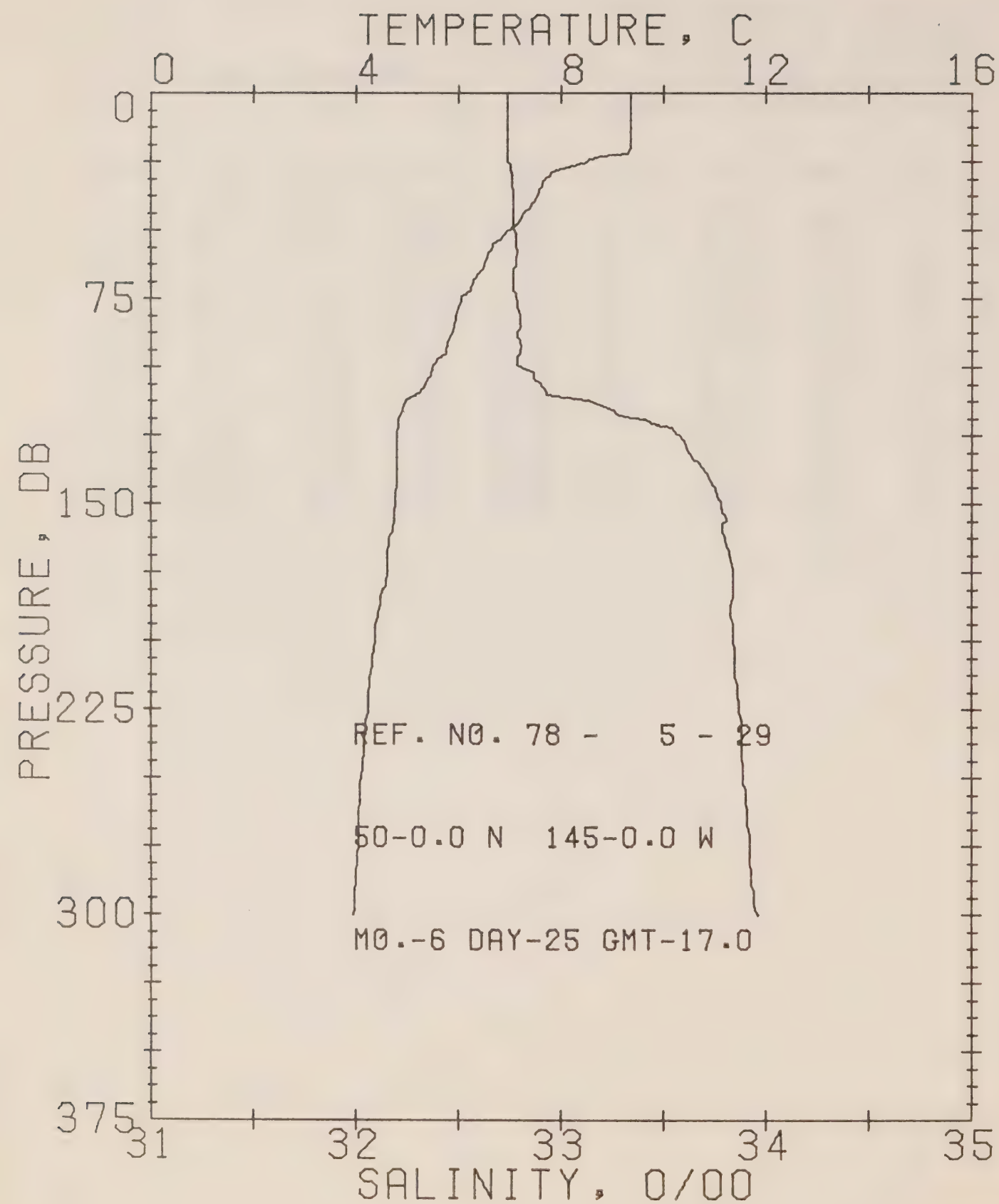
DATE 24/ 6/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 186 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 9.30 | 32.74 | 0 | 25.33 | 265.6 | .00 | .00 | 1485. |
| 10 | 9.27 | 32.74 | 10 | 25.33 | 265.4 | .27 | .01 | 1485. |
| 20 | 8.15 | 32.75 | 20 | 25.51 | 248.1 | .52 | .05 | 1481. |
| 30 | 7.45 | 32.77 | 30 | 25.63 | 237.5 | .76 | .11 | 1478. |
| 50 | 6.66 | 32.79 | 50 | 25.75 | 226.2 | 1.23 | .30 | 1476. |
| 75 | 5.96 | 32.81 | 75 | 25.85 | 216.5 | 1.78 | .65 | 1473. |
| 100 | 5.48 | 32.86 | 99 | 25.95 | 207.3 | 2.31 | 1.13 | 1472. |
| 125 | 4.81 | 33.53 | 124 | 26.55 | 150.4 | 2.77 | 1.65 | 1470. |
| 150 | 4.77 | 33.79 | 149 | 26.77 | 130.4 | 3.11 | 2.13 | 1471. |
| 175 | 4.56 | 33.82 | 174 | 26.81 | 126.2 | 3.43 | 2.66 | 1470. |
| 200 | 4.35 | 33.85 | 199 | 26.86 | 121.9 | 3.74 | 3.26 | 1470. |
| 225 | 4.20 | 33.87 | 223 | 26.89 | 119.1 | 4.05 | 3.91 | 1470. |
| 250 | 4.10 | 33.89 | 248 | 26.92 | 116.8 | 4.34 | 4.62 | 1470. |
| 300 | 3.97 | 33.95 | 298 | 26.98 | 111.4 | 4.91 | 6.22 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 29

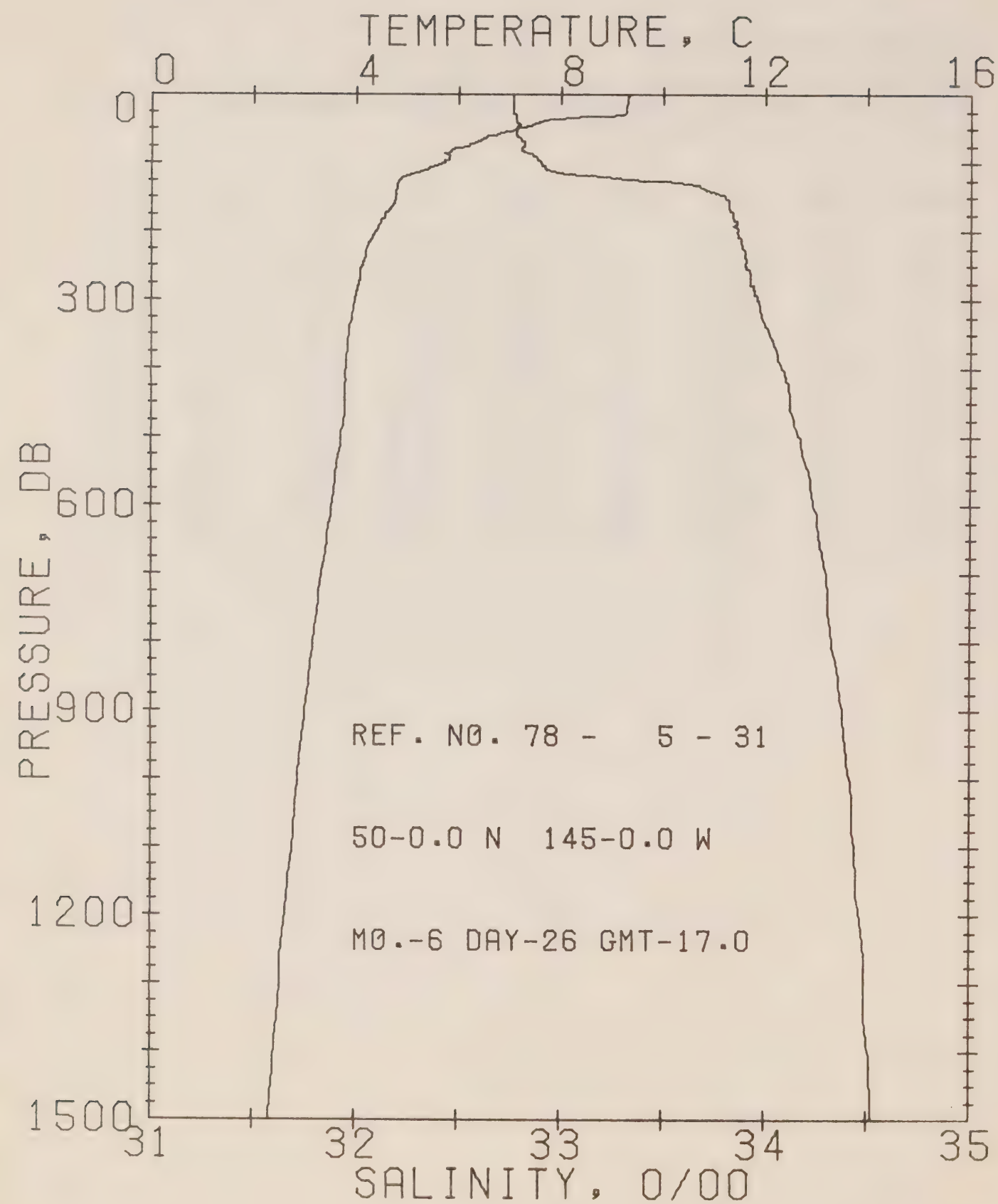
DATE 25/ 6/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 189 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 9.37 | 32.74 | 0 | 25.32 | 266.7 | .00 | .00 | 1485. |
| 10 | 9.37 | 32.74 | 10 | 25.32 | 266.9 | .27 | .01 | 1485. |
| 20 | 9.35 | 32.74 | 20 | 25.32 | 266.7 | .53 | .05 | 1485. |
| 30 | 7.79 | 32.76 | 30 | 25.57 | 242.8 | .79 | .12 | 1480. |
| 50 | 7.00 | 32.77 | 50 | 25.69 | 231.7 | 1.26 | .31 | 1477. |
| 75 | 6.06 | 32.78 | 75 | 25.82 | 219.6 | 1.83 | .67 | 1474. |
| 100 | 5.52 | 32.80 | 99 | 25.90 | 212.5 | 2.37 | 1.15 | 1472. |
| 125 | 4.81 | 33.56 | 124 | 26.58 | 147.5 | 2.83 | 1.68 | 1470. |
| 150 | 4.77 | 33.78 | 149 | 26.76 | 131.2 | 3.17 | 2.16 | 1471. |
| 175 | 4.60 | 33.84 | 174 | 26.82 | 125.1 | 3.49 | 2.69 | 1471. |
| 200 | 4.36 | 33.84 | 199 | 26.85 | 122.8 | 3.80 | 3.29 | 1470. |
| 225 | 4.23 | 33.87 | 223 | 26.89 | 119.4 | 4.11 | 3.94 | 1470. |
| 250 | 4.11 | 33.89 | 248 | 26.92 | 116.9 | 4.40 | 4.66 | 1470. |
| 300 | 3.97 | 33.95 | 298 | 26.98 | 111.4 | 4.97 | 6.26 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

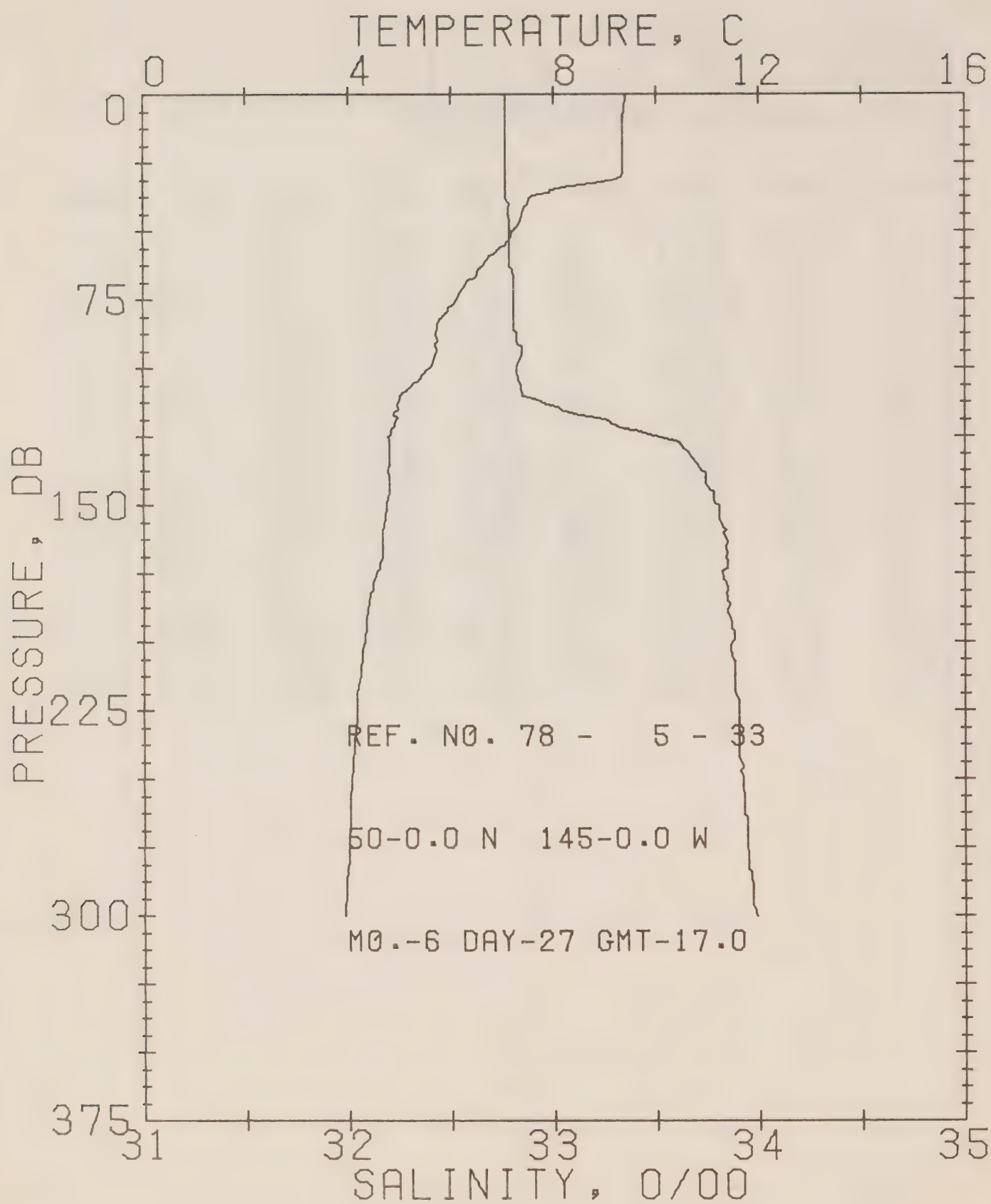
REFERENCE NO. 78- 5- 31 DATE 26/ 6/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 288 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 9.33 | 32.77 | 0 | 25.34 | 263.9 | .00 | .00 | 1485. |
| 10 | 9.30 | 32.77 | 10 | 25.35 | 263.6 | .26 | .01 | 1485. |
| 20 | 9.28 | 32.77 | 20 | 25.35 | 263.5 | .53 | .05 | 1485. |
| 30 | 9.21 | 32.78 | 30 | 25.37 | 262.1 | .79 | .12 | 1485. |
| 50 | 7.16 | 32.79 | 50 | 25.68 | 232.5 | 1.27 | .32 | 1478. |
| 75 | 6.20 | 32.82 | 75 | 25.83 | 218.5 | 1.84 | .67 | 1474. |
| 100 | 5.71 | 32.90 | 99 | 25.95 | 207.0 | 2.37 | 1.15 | 1473. |
| 125 | 4.85 | 33.35 | 124 | 26.41 | 163.7 | 2.85 | 1.70 | 1470. |
| 150 | 4.78 | 33.80 | 149 | 26.77 | 129.8 | 3.20 | 2.19 | 1471. |
| 175 | 4.56 | 33.84 | 174 | 26.83 | 124.7 | 3.52 | 2.71 | 1471. |
| 200 | 4.40 | 33.87 | 199 | 26.87 | 121.0 | 3.82 | 3.30 | 1470. |
| 225 | 4.22 | 33.89 | 223 | 26.90 | 117.7 | 4.12 | 3.95 | 1470. |
| 250 | 4.12 | 33.90 | 248 | 26.92 | 116.2 | 4.41 | 4.65 | 1470. |
| 300 | 3.98 | 33.96 | 298 | 26.98 | 110.6 | 4.98 | 6.24 | 1470. |
| 400 | 3.81 | 34.07 | 397 | 27.09 | 101.3 | 6.04 | 10.00 | 1471. |
| 500 | 3.71 | 34.16 | 496 | 27.17 | 94.8 | 7.02 | 14.49 | 1473. |
| 600 | 3.54 | 34.23 | 595 | 27.24 | 88.3 | 7.93 | 19.60 | 1474. |
| 800 | 3.19 | 34.33 | 793 | 27.35 | 78.9 | 9.59 | 31.39 | 1476. |
| 1000 | 2.89 | 34.41 | 990 | 27.45 | 70.7 | 11.08 | 45.02 | 1478. |
| 1200 | 2.65 | 34.46 | 1188 | 27.51 | 65.6 | 12.44 | 60.25 | 1480. |
| 1500 | 2.33 | 34.52 | 1484 | 27.58 | 59.0 | 14.29 | 85.75 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 33

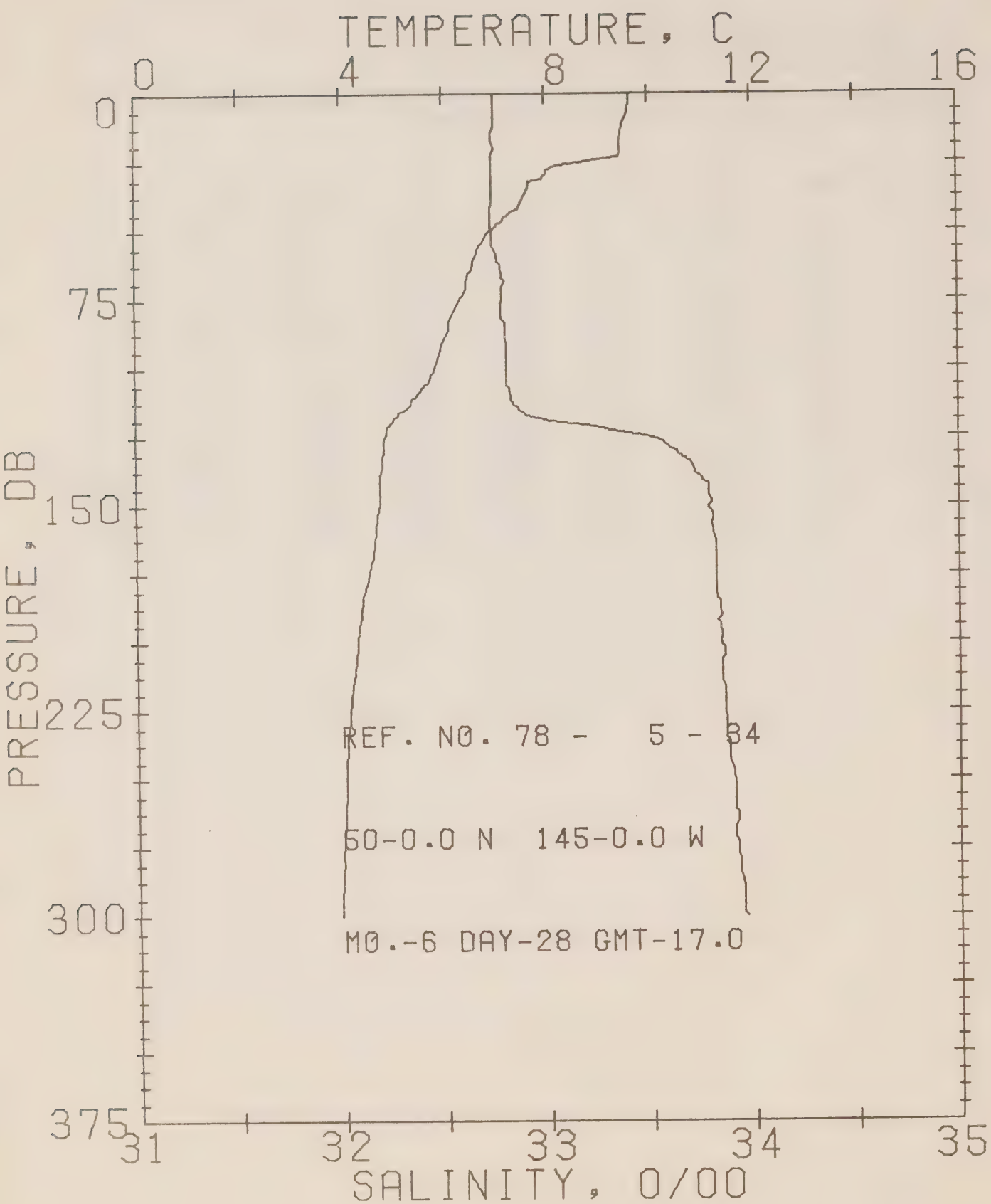
DATE 27/ 6/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 203 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 9.40 | 32.77 | 0 | 25.33 | 264.9 | .00 | .00 | 1485. |
| 10 | 9.37 | 32.77 | 10 | 25.34 | 264.6 | .26 | .01 | 1485. |
| 20 | 9.37 | 32.77 | 20 | 25.34 | 264.8 | .53 | .05 | 1486. |
| 30 | 9.35 | 32.77 | 30 | 25.34 | 264.6 | .79 | .12 | 1486. |
| 50 | 7.21 | 32.79 | 50 | 25.67 | 233.2 | 1.28 | .32 | 1478. |
| 75 | 6.12 | 32.81 | 75 | 25.83 | 218.3 | 1.84 | .68 | 1474. |
| 100 | 5.61 | 32.82 | 99 | 25.90 | 211.9 | 2.38 | 1.15 | 1472. |
| 125 | 4.83 | 33.47 | 124 | 26.51 | 154.8 | 2.86 | 1.70 | 1470. |
| 150 | 4.76 | 33.79 | 149 | 26.77 | 130.3 | 3.20 | 2.18 | 1471. |
| 175 | 4.58 | 33.83 | 174 | 26.82 | 125.8 | 3.52 | 2.70 | 1471. |
| 200 | 4.33 | 33.88 | 199 | 26.88 | 119.4 | 3.82 | 3.29 | 1470. |
| 225 | 4.17 | 33.90 | 223 | 26.92 | 116.5 | 4.12 | 3.93 | 1470. |
| 250 | 4.06 | 33.92 | 248 | 26.94 | 114.4 | 4.41 | 4.63 | 1470. |
| 300 | 3.92 | 33.98 | 298 | 27.01 | 108.7 | 4.97 | 6.19 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 34

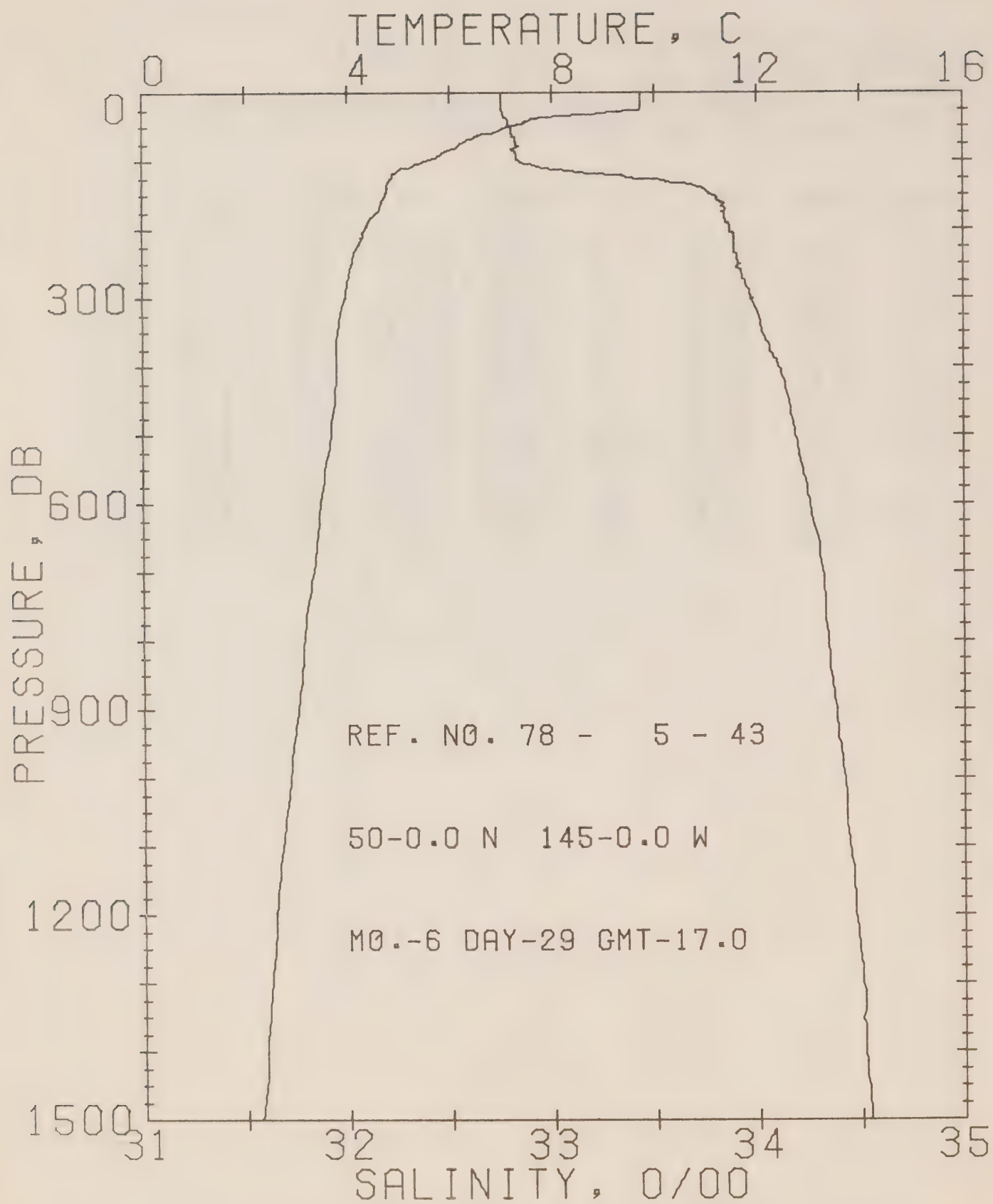
DATE 28/ 6/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 218 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 9.66 | 32.75 | 0 | 25.28 | 270.4 | .00 | .00 | 1486. |
| 10 | 9.55 | 32.75 | 10 | 25.29 | 268.9 | .27 | .01 | 1486. |
| 20 | 9.46 | 32.75 | 20 | 25.31 | 267.7 | .54 | .05 | 1486. |
| 30 | 7.99 | 32.74 | 30 | 25.53 | 247.1 | .80 | .12 | 1480. |
| 50 | 6.93 | 32.74 | 50 | 25.67 | 233.5 | 1.28 | .32 | 1477. |
| 75 | 6.34 | 32.79 | 75 | 25.79 | 222.5 | 1.84 | .68 | 1475. |
| 100 | 5.83 | 32.81 | 99 | 25.87 | 215.2 | 2.39 | 1.16 | 1473. |
| 125 | 4.87 | 33.46 | 124 | 26.49 | 155.8 | 2.89 | 1.74 | 1470. |
| 150 | 4.76 | 33.80 | 149 | 26.77 | 129.6 | 3.24 | 2.22 | 1471. |
| 175 | 4.54 | 33.82 | 174 | 26.81 | 125.9 | 3.56 | 2.75 | 1470. |
| 200 | 4.30 | 33.84 | 199 | 26.86 | 121.8 | 3.87 | 3.34 | 1470. |
| 225 | 4.14 | 33.86 | 223 | 26.89 | 119.2 | 4.17 | 3.99 | 1470. |
| 250 | 4.04 | 33.90 | 248 | 26.93 | 115.4 | 4.46 | 4.70 | 1470. |
| 300 | 3.95 | 33.95 | 298 | 26.98 | 111.1 | 5.03 | 6.29 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

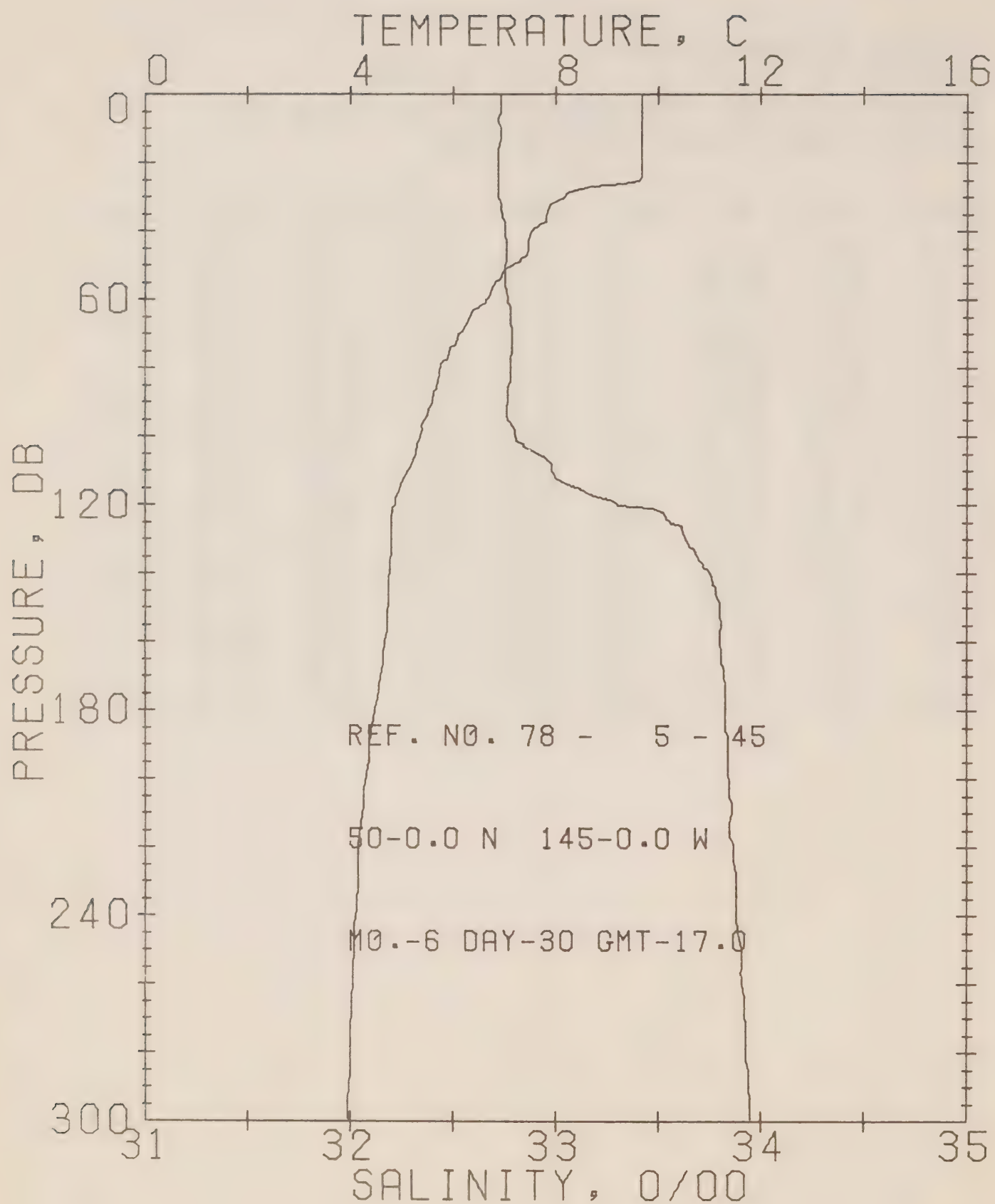
REFERENCE NO. 78- 5- 43 DATE 29/ 6/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 326 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 9.73 | 32.75 | 0 | 25.26 | 271.5 | .00 | .00 | 1487. |
| 10 | 9.73 | 32.75 | 10 | 25.26 | 271.7 | .27 | .01 | 1487. |
| 20 | 9.73 | 32.75 | 20 | 25.26 | 271.9 | .54 | .06 | 1487. |
| 30 | 9.07 | 32.76 | 30 | 25.38 | 261.3 | .81 | .12 | 1485. |
| 50 | 7.19 | 32.79 | 50 | 25.68 | 232.6 | 1.30 | .32 | 1478. |
| 75 | 6.21 | 32.83 | 75 | 25.84 | 218.0 | 1.86 | .68 | 1474. |
| 100 | 5.50 | 32.84 | 99 | 25.93 | 209.1 | 2.39 | 1.16 | 1472. |
| 125 | 4.86 | 33.41 | 124 | 26.45 | 159.9 | 2.87 | 1.69 | 1470. |
| 150 | 4.76 | 33.78 | 149 | 26.76 | 131.0 | 3.22 | 2.18 | 1471. |
| 175 | 4.58 | 33.83 | 174 | 26.82 | 125.5 | 3.53 | 2.71 | 1471. |
| 200 | 4.34 | 33.87 | 199 | 26.88 | 120.3 | 3.84 | 3.30 | 1470. |
| 225 | 4.22 | 33.89 | 223 | 26.90 | 117.7 | 4.14 | 3.94 | 1470. |
| 250 | 4.10 | 33.91 | 248 | 26.93 | 115.2 | 4.43 | 4.64 | 1470. |
| 300 | 3.97 | 33.97 | 298 | 26.99 | 109.8 | 4.99 | 6.22 | 1470. |
| 400 | 3.80 | 34.10 | 397 | 27.11 | 99.2 | 6.04 | 9.95 | 1471. |
| 500 | 3.68 | 34.18 | 496 | 27.19 | 92.7 | 7.00 | 14.33 | 1473. |
| 600 | 3.48 | 34.25 | 595 | 27.26 | 86.3 | 7.89 | 19.35 | 1473. |
| 800 | 3.14 | 34.34 | 793 | 27.37 | 77.3 | 9.51 | 30.88 | 1475. |
| 1000 | 2.87 | 34.41 | 990 | 27.45 | 70.1 | 10.99 | 44.44 | 1478. |
| 1200 | 2.58 | 34.47 | 1188 | 27.52 | 64.0 | 12.33 | 59.42 | 1480. |
| 1500 | 2.30 | 34.54 | 1483 | 27.60 | 57.2 | 14.15 | 84.40 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 45

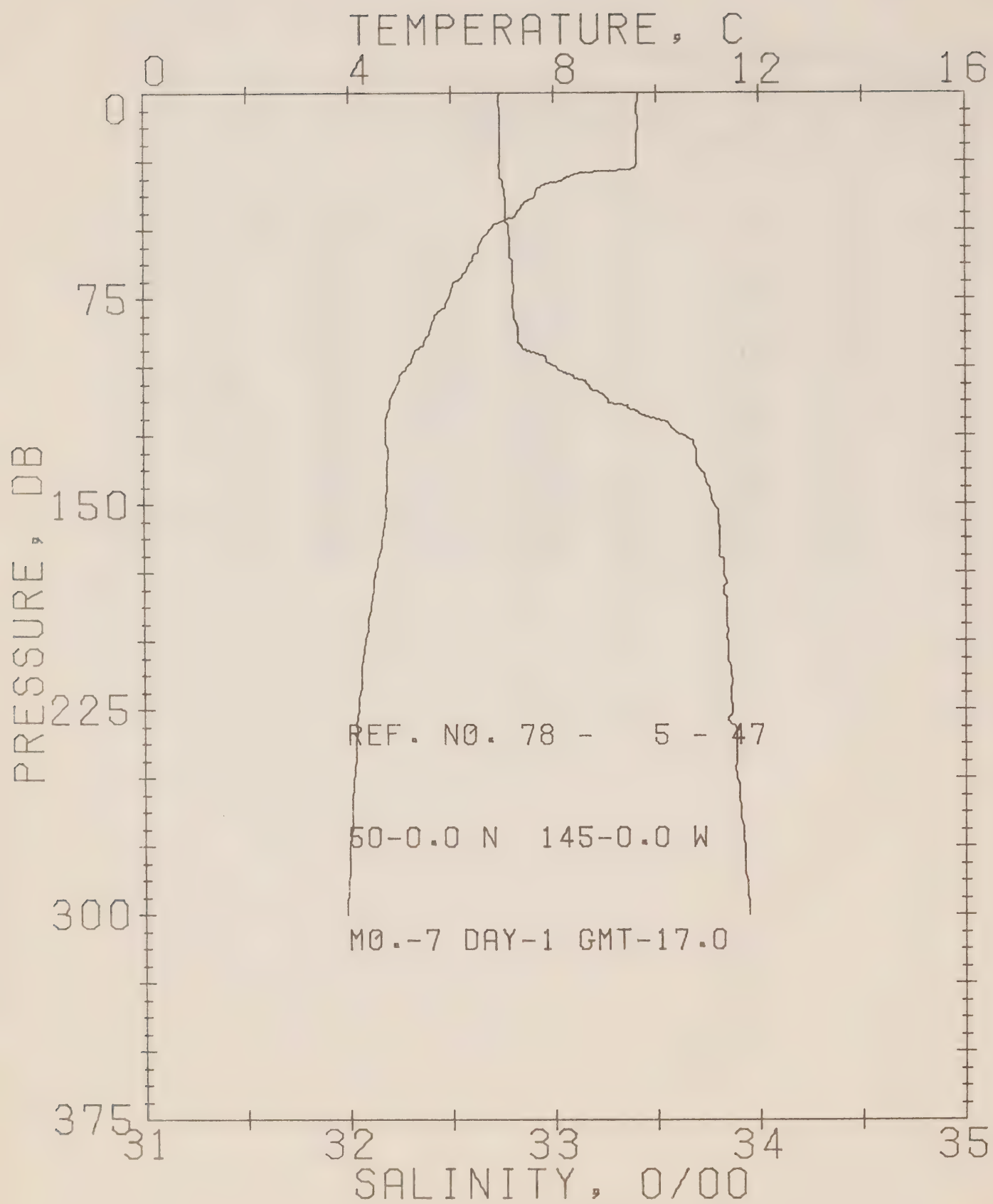
DATE 30/ 6/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 196 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 9.68 | 32.73 | 0 | 25.26 | 272.2 | .00 | .00 | 1466. |
| 10 | 9.68 | 32.73 | 10 | 25.26 | 272.4 | .27 | .01 | 1466. |
| 20 | 9.67 | 32.72 | 20 | 25.25 | 273.2 | .55 | .06 | 1467. |
| 30 | 8.17 | 32.72 | 30 | 25.48 | 251.1 | .81 | .12 | 1461. |
| 50 | 7.17 | 32.75 | 50 | 25.65 | 235.4 | 1.30 | .32 | 1478. |
| 75 | 5.92 | 32.79 | 75 | 25.84 | 217.5 | 1.86 | .68 | 1475. |
| 100 | 5.38 | 32.80 | 99 | 25.92 | 210.6 | 2.40 | 1.16 | 1471. |
| 125 | 4.81 | 33.54 | 124 | 26.57 | 149.0 | 2.86 | 1.69 | 1470. |
| 150 | 4.74 | 33.80 | 149 | 26.78 | 129.3 | 3.21 | 2.17 | 1471. |
| 175 | 4.56 | 33.83 | 174 | 26.82 | 125.4 | 3.53 | 2.70 | 1470. |
| 200 | 4.31 | 33.84 | 199 | 26.85 | 122.3 | 3.83 | 3.29 | 1470. |
| 225 | 4.16 | 33.87 | 223 | 26.89 | 118.6 | 4.14 | 3.94 | 1470. |
| 250 | 4.07 | 33.90 | 248 | 26.93 | 115.6 | 4.43 | 4.65 | 1470. |
| 300 | 3.96 | 33.95 | 298 | 26.98 | 111.2 | 5.00 | 6.24 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 47

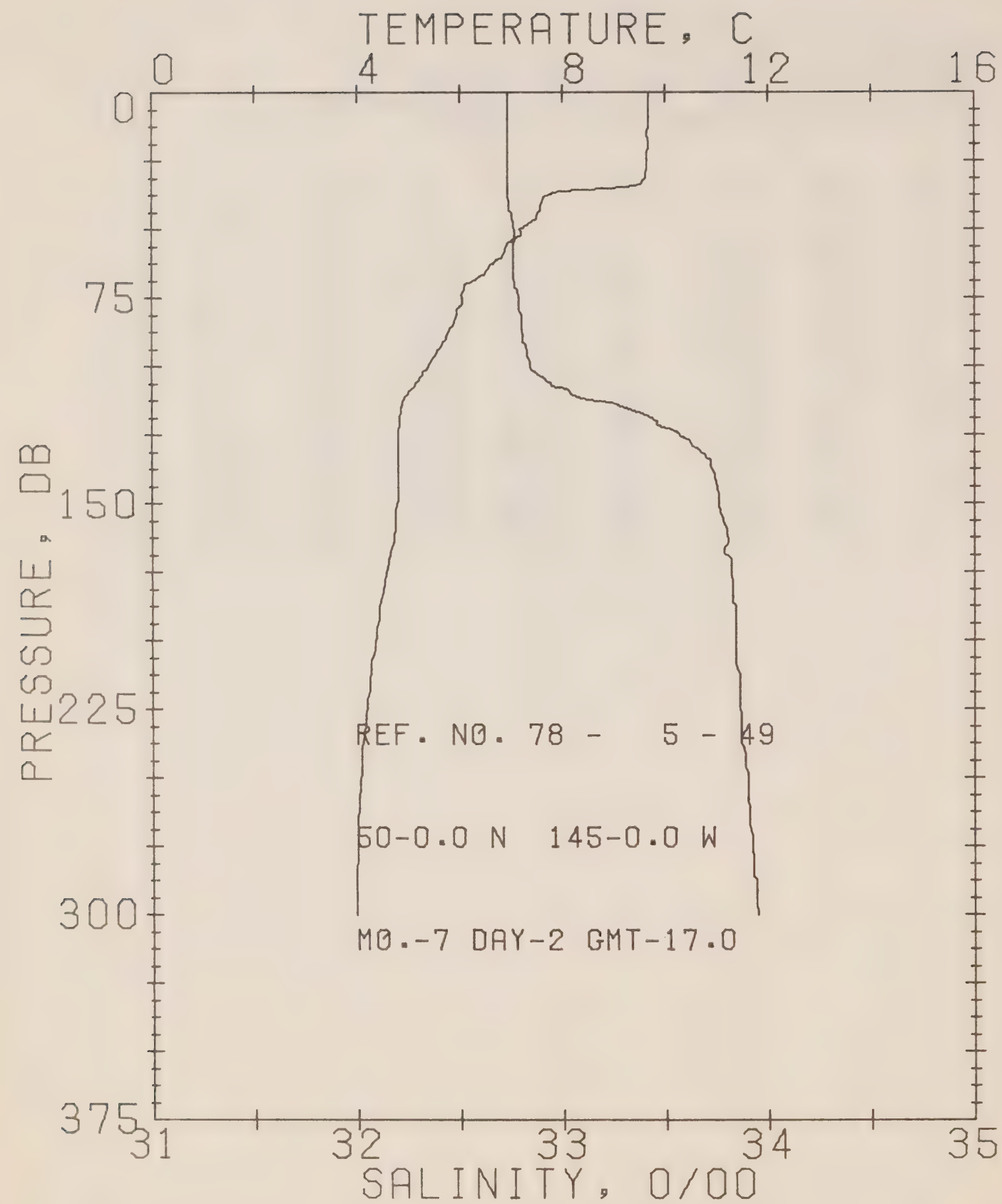
DATE 1/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 208 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 9.65 | 32.74 | 0 | 25.27 | 271.0 | .00 | .00 | 1486. |
| 10 | 9.65 | 32.74 | 10 | 25.27 | 271.2 | .27 | .01 | 1486. |
| 20 | 9.64 | 32.74 | 20 | 25.27 | 271.2 | .54 | .06 | 1486. |
| 30 | 8.40 | 32.74 | 30 | 25.46 | 252.9 | .81 | .12 | 1482. |
| 50 | 6.77 | 32.78 | 50 | 25.73 | 228.2 | 1.29 | .32 | 1476. |
| 75 | 5.97 | 32.80 | 75 | 25.84 | 217.3 | 1.84 | .67 | 1473. |
| 100 | 5.15 | 33.00 | 99 | 26.10 | 193.4 | 2.37 | 1.14 | 1471. |
| 125 | 4.71 | 33.61 | 124 | 26.63 | 143.2 | 2.79 | 1.61 | 1470. |
| 150 | 4.73 | 33.77 | 149 | 26.76 | 131.1 | 3.13 | 2.09 | 1471. |
| 175 | 4.54 | 33.83 | 174 | 26.82 | 125.2 | 3.45 | 2.62 | 1470. |
| 200 | 4.33 | 33.84 | 199 | 26.85 | 122.5 | 3.75 | 3.21 | 1470. |
| 225 | 4.20 | 33.87 | 223 | 26.89 | 119.0 | 4.06 | 3.86 | 1470. |
| 250 | 4.10 | 33.89 | 248 | 26.92 | 116.7 | 4.35 | 4.57 | 1470. |
| 300 | 3.95 | 33.95 | 298 | 26.98 | 111.1 | 4.92 | 6.17 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 49

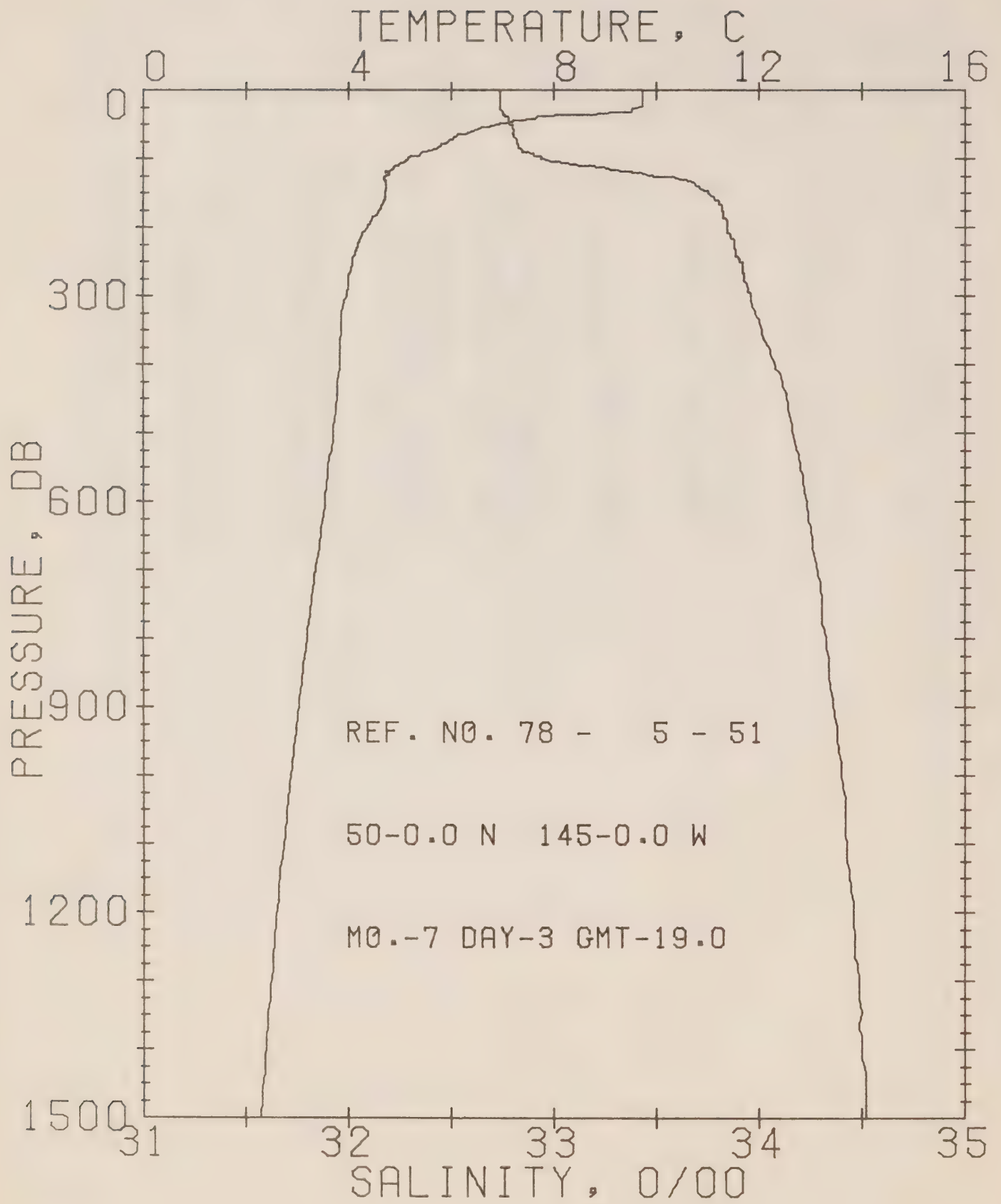
DATE 2/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 214 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 9.67 | 32.73 | 0 | 25.26 | 272.0 | .00 | .00 | 1486. |
| 10 | 9.67 | 32.73 | 10 | 25.26 | 272.2 | .27 | .01 | 1486. |
| 20 | 9.67 | 32.73 | 20 | 25.26 | 272.4 | .54 | .06 | 1487. |
| 30 | 9.63 | 32.73 | 30 | 25.26 | 272.0 | .82 | .12 | 1487. |
| 50 | 7.20 | 32.77 | 50 | 25.66 | 234.7 | 1.31 | .33 | 1478. |
| 75 | 6.04 | 32.79 | 75 | 25.83 | 218.8 | 1.88 | .69 | 1474. |
| 100 | 5.41 | 32.84 | 99 | 25.94 | 208.1 | 2.42 | 1.17 | 1471. |
| 125 | 4.80 | 33.56 | 124 | 26.58 | 147.6 | 2.87 | 1.68 | 1470. |
| 150 | 4.79 | 33.76 | 149 | 26.74 | 132.9 | 3.21 | 2.16 | 1471. |
| 175 | 4.58 | 33.82 | 174 | 26.81 | 126.4 | 3.53 | 2.69 | 1471. |
| 200 | 4.36 | 33.84 | 199 | 26.85 | 122.8 | 3.85 | 3.29 | 1470. |
| 225 | 4.18 | 33.86 | 223 | 26.88 | 119.6 | 4.15 | 3.94 | 1470. |
| 250 | 4.07 | 33.90 | 248 | 26.93 | 115.7 | 4.44 | 4.65 | 1470. |
| 300 | 3.97 | 33.95 | 298 | 26.98 | 111.5 | 5.01 | 6.25 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

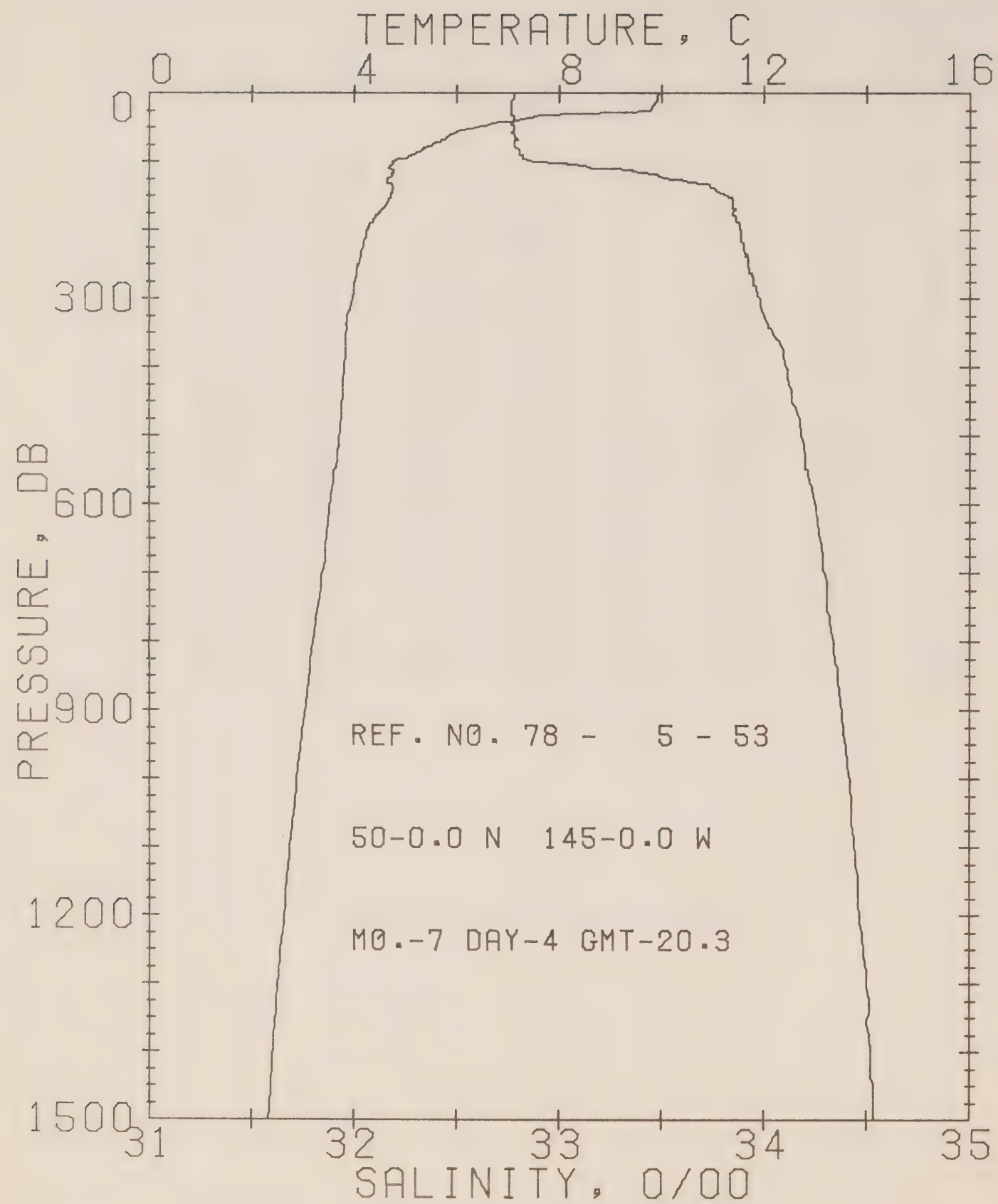
REFERENCE NO. 78- 5- 51 DATE 3/ 7/78

POSITION 50- .0N, 145- .0W GMT 19.0

RESULTS OF STP CAST 337 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 9.74 | 32.74 | 0 | 25.26 | 272.4 | .00 | .00 | 1487. |
| 10 | 9.74 | 32.74 | 10 | 25.26 | 272.6 | .27 | .01 | 1487. |
| 20 | 9.74 | 32.74 | 20 | 25.26 | 272.8 | .55 | .06 | 1487. |
| 30 | 9.53 | 32.74 | 30 | 25.29 | 269.4 | .82 | .12 | 1486. |
| 50 | 6.94 | 32.79 | 50 | 25.71 | 229.6 | 1.31 | .32 | 1477. |
| 75 | 5.95 | 32.82 | 75 | 25.86 | 215.5 | 1.86 | .67 | 1473. |
| 100 | 5.16 | 32.95 | 99 | 26.05 | 197.4 | 2.38 | 1.14 | 1471. |
| 125 | 4.74 | 33.48 | 124 | 26.53 | 152.9 | 2.82 | 1.64 | 1470. |
| 150 | 4.73 | 33.75 | 149 | 26.74 | 133.0 | 3.17 | 2.13 | 1471. |
| 175 | 4.61 | 33.82 | 174 | 26.81 | 126.7 | 3.49 | 2.66 | 1471. |
| 200 | 4.37 | 33.85 | 199 | 26.86 | 122.1 | 3.80 | 3.25 | 1470. |
| 225 | 4.20 | 33.88 | 223 | 26.90 | 118.3 | 4.10 | 3.91 | 1470. |
| 250 | 4.08 | 33.91 | 248 | 26.93 | 115.1 | 4.39 | 4.61 | 1470. |
| 300 | 3.98 | 33.96 | 298 | 26.98 | 110.7 | 4.96 | 6.20 | 1470. |
| 400 | 3.84 | 34.07 | 397 | 27.09 | 101.8 | 6.02 | 9.98 | 1471. |
| 500 | 3.71 | 34.16 | 496 | 27.17 | 94.5 | 7.00 | 14.45 | 1473. |
| 600 | 3.55 | 34.23 | 595 | 27.24 | 88.6 | 7.91 | 19.56 | 1474. |
| 800 | 3.20 | 34.32 | 793 | 27.35 | 79.0 | 9.58 | 31.47 | 1476. |
| 1000 | 2.89 | 34.40 | 990 | 27.44 | 71.4 | 11.09 | 45.26 | 1478. |
| 1200 | 2.62 | 34.46 | 1188 | 27.51 | 65.2 | 12.46 | 60.60 | 1480. |
| 1500 | 2.31 | 34.52 | 1484 | 27.58 | 58.8 | 14.32 | 86.09 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 53

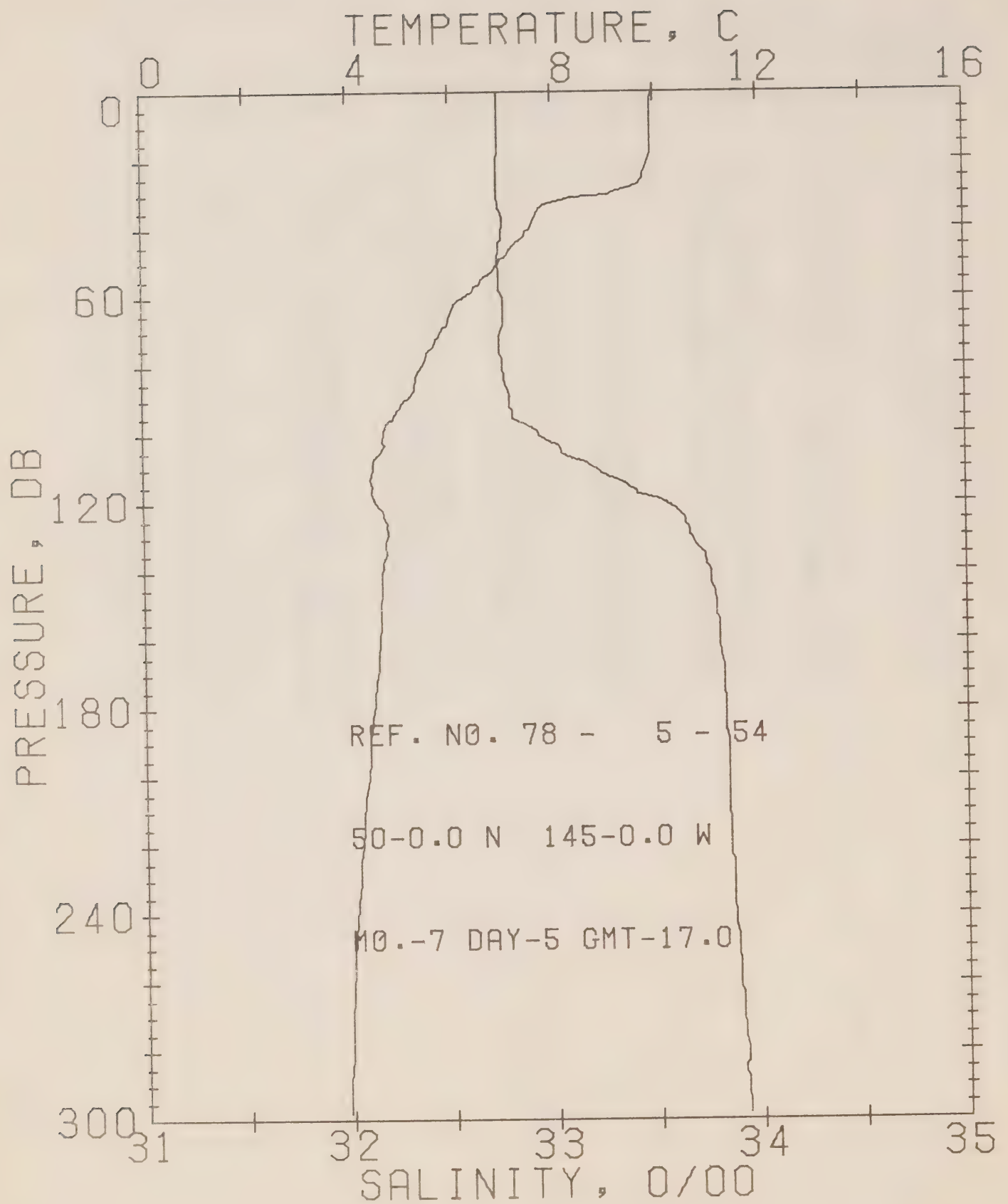
DATE 4/ 7/78

POSITION 50- .0N, 145- .0W GMT 20.3

RESULTS OF STP CAST 341 POINTS TAKEN FROM ANALOG TRACE

BISETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 9.94 | 32.78 | 0 | 25.25 | 272.6 | .00 | .00 | 1487. |
| 10 | 9.92 | 32.78 | 10 | 25.25 | 272.7 | .27 | .01 | 1487. |
| 20 | 9.82 | 32.77 | 20 | 25.27 | 271.8 | .54 | .06 | 1487. |
| 30 | 8.45 | 32.77 | 30 | 25.48 | 251.4 | .81 | .12 | 1482. |
| 50 | 6.47 | 32.78 | 50 | 25.76 | 224.5 | 1.28 | .31 | 1475. |
| 75 | 5.53 | 32.78 | 75 | 25.88 | 213.7 | 1.82 | .66 | 1471. |
| 100 | 4.77 | 32.90 | 99 | 26.06 | 196.8 | 2.34 | 1.12 | 1469. |
| 125 | 4.68 | 33.52 | 124 | 26.56 | 149.1 | 2.77 | 1.60 | 1470. |
| 150 | 4.72 | 33.81 | 149 | 26.79 | 128.4 | 3.11 | 2.08 | 1471. |
| 175 | 4.49 | 33.85 | 174 | 26.84 | 123.2 | 3.42 | 2.59 | 1470. |
| 200 | 4.28 | 33.88 | 199 | 26.89 | 118.7 | 3.72 | 3.17 | 1470. |
| 225 | 4.18 | 33.90 | 223 | 26.92 | 116.6 | 4.01 | 3.81 | 1470. |
| 250 | 4.10 | 33.92 | 248 | 26.94 | 114.5 | 4.30 | 4.50 | 1470. |
| 300 | 3.97 | 33.98 | 298 | 27.00 | 109.4 | 4.86 | 6.07 | 1470. |
| 400 | 3.82 | 34.10 | 397 | 27.11 | 99.2 | 5.90 | 9.77 | 1471. |
| 500 | 3.73 | 34.18 | 496 | 27.18 | 93.2 | 6.86 | 14.19 | 1475. |
| 600 | 3.55 | 34.24 | 595 | 27.25 | 87.3 | 7.77 | 19.26 | 1474. |
| 800 | 3.21 | 34.34 | 793 | 27.36 | 78.3 | 9.43 | 31.04 | 1476. |
| 1000 | 2.90 | 34.41 | 990 | 27.45 | 70.5 | 10.91 | 44.67 | 1478. |
| 1200 | 2.66 | 34.46 | 1188 | 27.51 | 65.5 | 12.27 | 59.83 | 1480. |
| 1500 | 2.34 | 34.53 | 1483 | 27.59 | 58.5 | 14.10 | 85.04 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

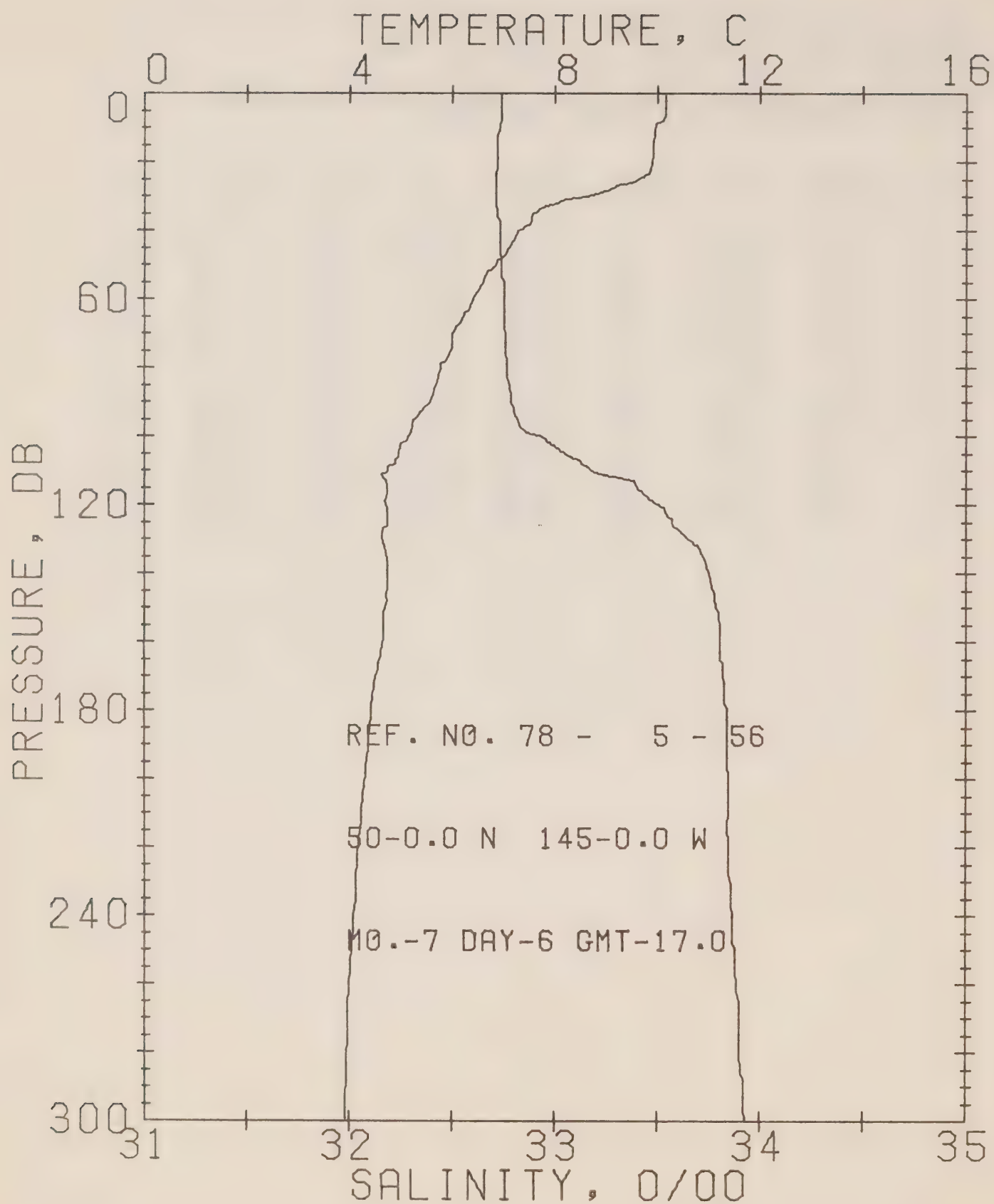
REFERENCE NO. 78- 5- 54 DATE 5/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 208 POINTS TAKEN FROM ANALOG TRACE

BISETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 9.96 | 32.74 | 0 | 25.22 | 275.8 | .00 | .00 | 1487. |
| 10 | 9.94 | 32.74 | 10 | 25.22 | 275.7 | .28 | .01 | 1487. |
| 20 | 9.89 | 32.73 | 20 | 25.22 | 275.9 | .55 | .06 | 1487. |
| 30 | 9.13 | 32.73 | 30 | 25.34 | 264.4 | .82 | .13 | 1485. |
| 50 | 6.97 | 32.73 | 50 | 25.66 | 234.5 | 1.31 | .32 | 1477. |
| 75 | 5.64 | 32.74 | 75 | 25.84 | 217.9 | 1.87 | .68 | 1472. |
| 100 | 4.70 | 32.92 | 99 | 26.09 | 194.1 | 2.39 | 1.14 | 1469. |
| 125 | 4.71 | 33.63 | 124 | 26.65 | 141.4 | 2.81 | 1.62 | 1470. |
| 150 | 4.62 | 33.79 | 149 | 26.78 | 128.8 | 3.14 | 2.09 | 1470. |
| 175 | 4.51 | 33.82 | 174 | 26.82 | 125.6 | 3.46 | 2.62 | 1470. |
| 200 | 4.35 | 33.84 | 199 | 26.85 | 122.6 | 3.77 | 3.21 | 1470. |
| 225 | 4.18 | 33.85 | 223 | 26.88 | 120.1 | 4.08 | 3.86 | 1470. |
| 250 | 4.05 | 33.88 | 248 | 26.91 | 117.0 | 4.37 | 4.58 | 1470. |
| 300 | 3.91 | 33.93 | 298 | 26.97 | 112.2 | 4.94 | 6.19 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 56

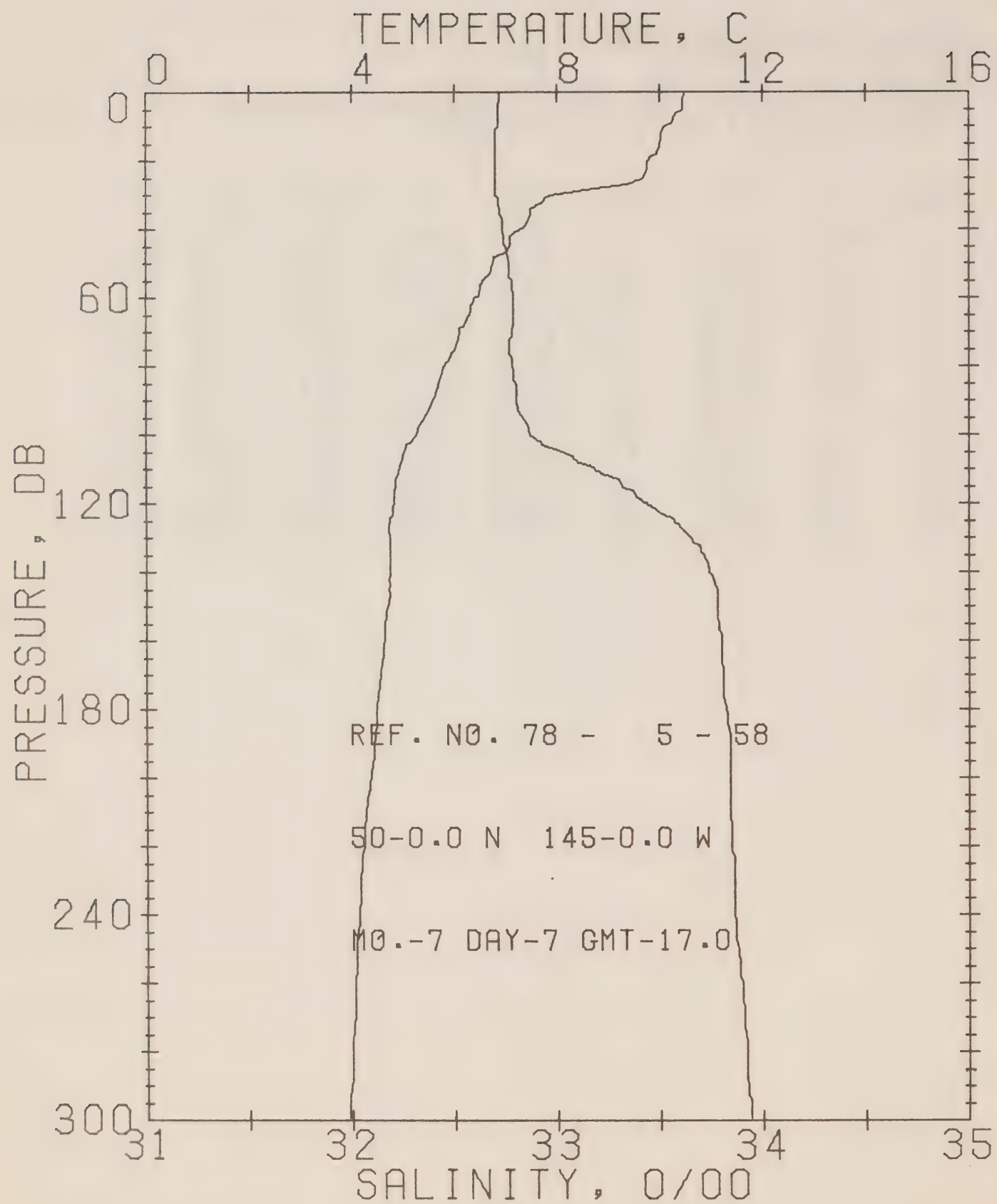
DATE 6/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 201 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 10.17 | 32.74 | 0 | 25.18 | 279.2 | .00 | .00 | 1488. |
| 10 | 9.96 | 32.73 | 10 | 25.21 | 276.8 | .28 | .01 | 1487. |
| 20 | 9.90 | 32.72 | 20 | 25.21 | 276.8 | .56 | .06 | 1487. |
| 30 | 8.68 | 32.71 | 30 | 25.40 | 259.1 | .83 | .13 | 1483. |
| 50 | 6.86 | 32.74 | 50 | 25.68 | 232.4 | 1.31 | .32 | 1476. |
| 75 | 5.99 | 32.76 | 75 | 25.81 | 220.5 | 1.87 | .68 | 1473. |
| 100 | 5.18 | 32.89 | 99 | 26.01 | 201.9 | 2.41 | 1.16 | 1471. |
| 125 | 4.76 | 33.57 | 124 | 26.59 | 146.5 | 2.83 | 1.64 | 1470. |
| 150 | 4.71 | 33.79 | 149 | 26.77 | 129.8 | 3.17 | 2.11 | 1471. |
| 175 | 4.47 | 33.83 | 174 | 26.83 | 124.5 | 3.49 | 2.64 | 1470. |
| 200 | 4.32 | 33.85 | 199 | 26.86 | 121.6 | 3.80 | 3.23 | 1470. |
| 225 | 4.16 | 33.85 | 223 | 26.88 | 120.2 | 4.10 | 3.88 | 1470. |
| 250 | 4.06 | 33.87 | 248 | 26.91 | 117.7 | 4.39 | 4.60 | 1470. |
| 300 | 3.93 | 33.92 | 298 | 26.96 | 112.8 | 4.97 | 6.21 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 58

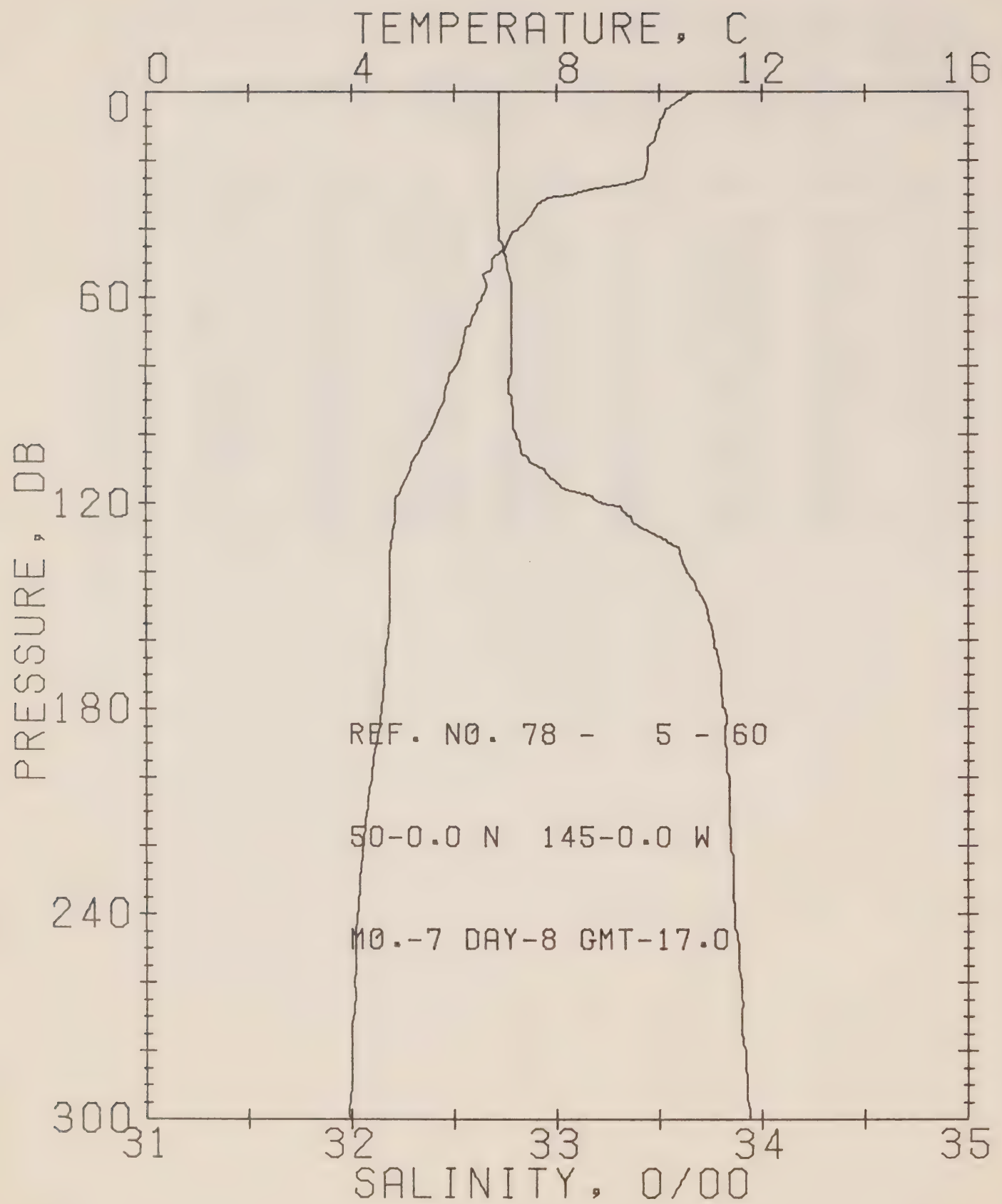
DATE 7/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 213 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 10.47 | 32.72 | 0 | 25.12 | 285.5 | .00 | .00 | 1489. |
| 10 | 10.10 | 32.71 | 10 | 25.17 | 280.5 | .28 | .01 | 1488. |
| 20 | 9.77 | 32.70 | 20 | 25.22 | 276.3 | .56 | .06 | 1487. |
| 30 | 7.91 | 32.70 | 30 | 25.51 | 249.0 | .83 | .13 | 1480. |
| 50 | 6.74 | 32.77 | 50 | 25.72 | 228.8 | 1.31 | .32 | 1476. |
| 75 | 6.02 | 32.77 | 75 | 25.81 | 220.1 | 1.87 | .67 | 1473. |
| 100 | 5.26 | 32.86 | 99 | 25.98 | 204.7 | 2.40 | 1.15 | 1471. |
| 125 | 4.76 | 33.56 | 124 | 26.59 | 147.1 | 2.84 | 1.65 | 1470. |
| 150 | 4.72 | 33.78 | 149 | 26.76 | 130.6 | 3.18 | 2.12 | 1471. |
| 175 | 4.53 | 33.81 | 174 | 26.81 | 126.6 | 3.50 | 2.65 | 1470. |
| 200 | 4.37 | 33.84 | 199 | 26.85 | 122.9 | 3.81 | 3.25 | 1470. |
| 225 | 4.19 | 33.86 | 223 | 26.88 | 119.7 | 4.11 | 3.91 | 1470. |
| 250 | 4.09 | 33.87 | 248 | 26.91 | 117.8 | 4.41 | 4.63 | 1470. |
| 300 | 3.96 | 33.94 | 298 | 26.97 | 112.0 | 4.98 | 6.23 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 60

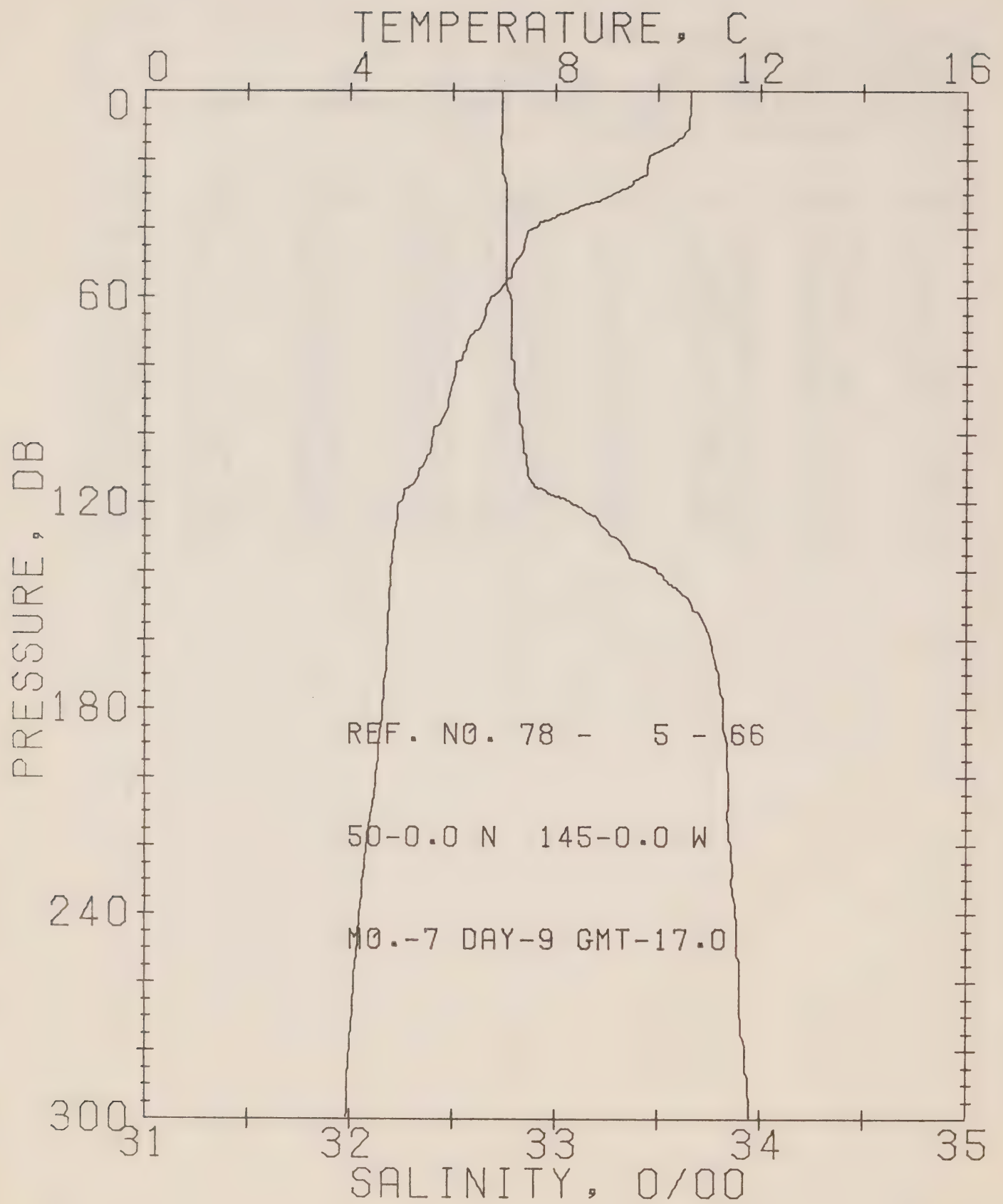
DATE 8/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 205 POINTS TAKEN FROM ANALOG TRACE

BISETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 10.64 | 32.72 | 0 | 25.09 | 288.3 | .00 | .00 | 1490. |
| 10 | 10.01 | 32.72 | 10 | 25.19 | 278.3 | .28 | .01 | 1488. |
| 20 | 9.78 | 32.72 | 20 | 25.23 | 274.9 | .56 | .06 | 1487. |
| 30 | 8.33 | 32.71 | 30 | 25.45 | 254.1 | .83 | .13 | 1482. |
| 50 | 6.75 | 32.75 | 50 | 25.71 | 230.0 | 1.31 | .32 | 1476. |
| 75 | 6.16 | 32.78 | 75 | 25.80 | 221.1 | 1.87 | .68 | 1474. |
| 100 | 5.51 | 32.80 | 99 | 25.90 | 212.5 | 2.41 | 1.16 | 1472. |
| 125 | 4.85 | 33.36 | 124 | 26.42 | 163.1 | 2.89 | 1.71 | 1470. |
| 150 | 4.75 | 33.72 | 149 | 26.71 | 135.4 | 3.26 | 2.22 | 1471. |
| 175 | 4.63 | 33.80 | 174 | 26.79 | 128.4 | 3.59 | 2.76 | 1471. |
| 200 | 4.40 | 33.83 | 199 | 26.84 | 123.7 | 3.90 | 3.36 | 1470. |
| 225 | 4.21 | 33.86 | 223 | 26.88 | 119.9 | 4.20 | 4.02 | 1470. |
| 250 | 4.09 | 33.89 | 248 | 26.91 | 116.9 | 4.50 | 4.74 | 1470. |
| 300 | 3.96 | 33.94 | 298 | 26.97 | 112.0 | 5.08 | 6.35 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 66

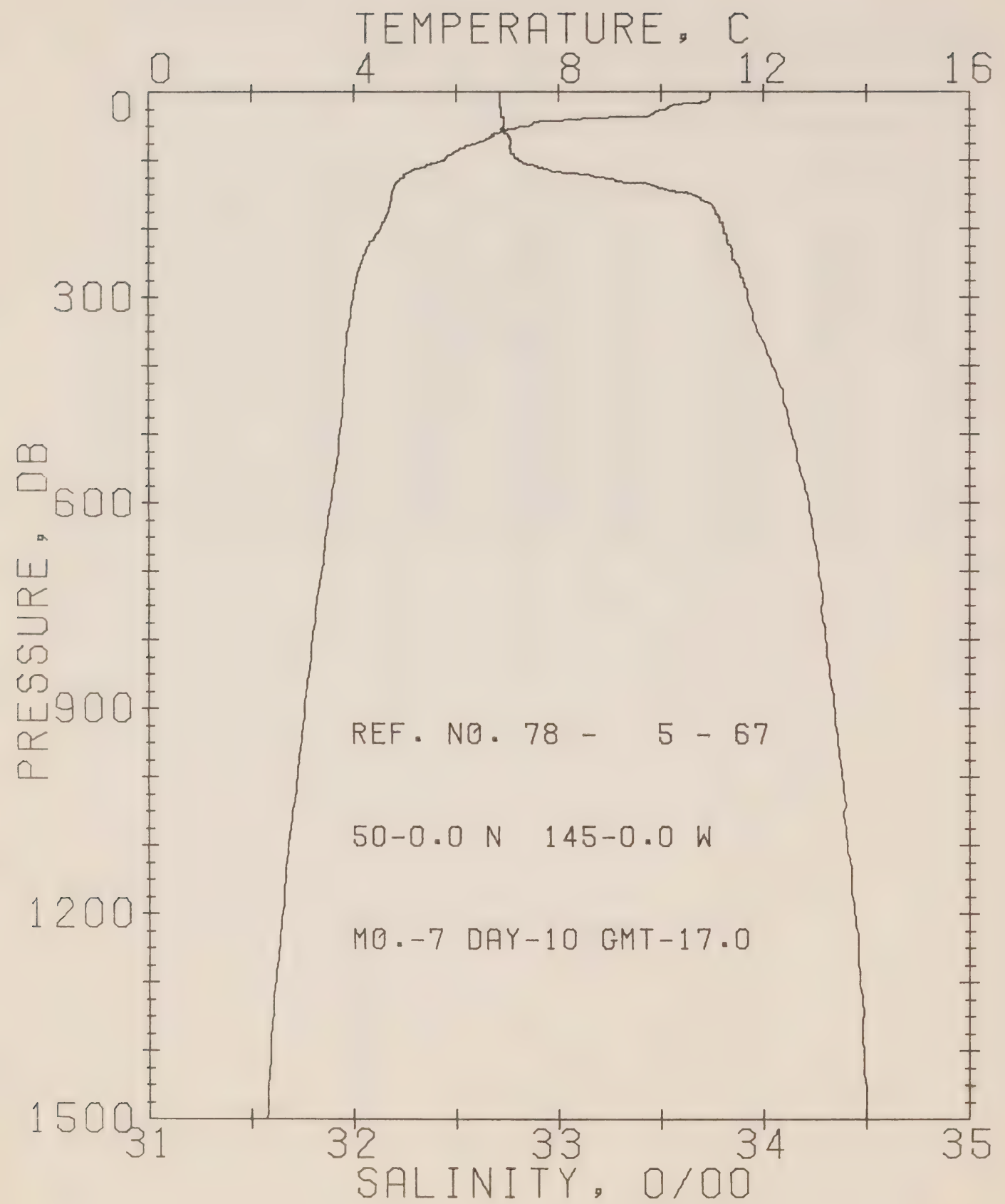
DATE 9/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 208 POINTS TAKEN FROM ANALOG TRACE

BISETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 10.64 | 32.74 | 0 | 25.10 | 286.8 | .00 | .00 | 1490. |
| 10 | 10.61 | 32.74 | 10 | 25.11 | 286.6 | .29 | .01 | 1490. |
| 20 | 9.82 | 32.74 | 20 | 25.24 | 274.1 | .57 | .06 | 1487. |
| 30 | 9.15 | 32.76 | 30 | 25.37 | 262.4 | .84 | .13 | 1485. |
| 50 | 7.21 | 32.76 | 50 | 25.65 | 235.4 | 1.33 | .32 | 1478. |
| 75 | 6.27 | 32.79 | 75 | 25.80 | 221.6 | 1.90 | .69 | 1474. |
| 100 | 5.63 | 32.84 | 99 | 25.92 | 210.6 | 2.44 | 1.17 | 1472. |
| 125 | 4.93 | 33.20 | 124 | 26.28 | 175.9 | 2.94 | 1.74 | 1470. |
| 150 | 4.77 | 33.66 | 149 | 26.66 | 140.1 | 3.33 | 2.29 | 1471. |
| 175 | 4.67 | 33.81 | 174 | 26.79 | 128.4 | 3.67 | 2.84 | 1471. |
| 200 | 4.52 | 33.85 | 199 | 26.84 | 123.9 | 3.98 | 3.44 | 1471. |
| 225 | 4.30 | 33.86 | 223 | 26.87 | 120.8 | 4.29 | 4.11 | 1470. |
| 250 | 4.15 | 33.89 | 248 | 26.91 | 117.3 | 4.58 | 4.83 | 1470. |
| 300 | 3.94 | 33.95 | 298 | 26.98 | 111.0 | 5.16 | 6.43 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 67

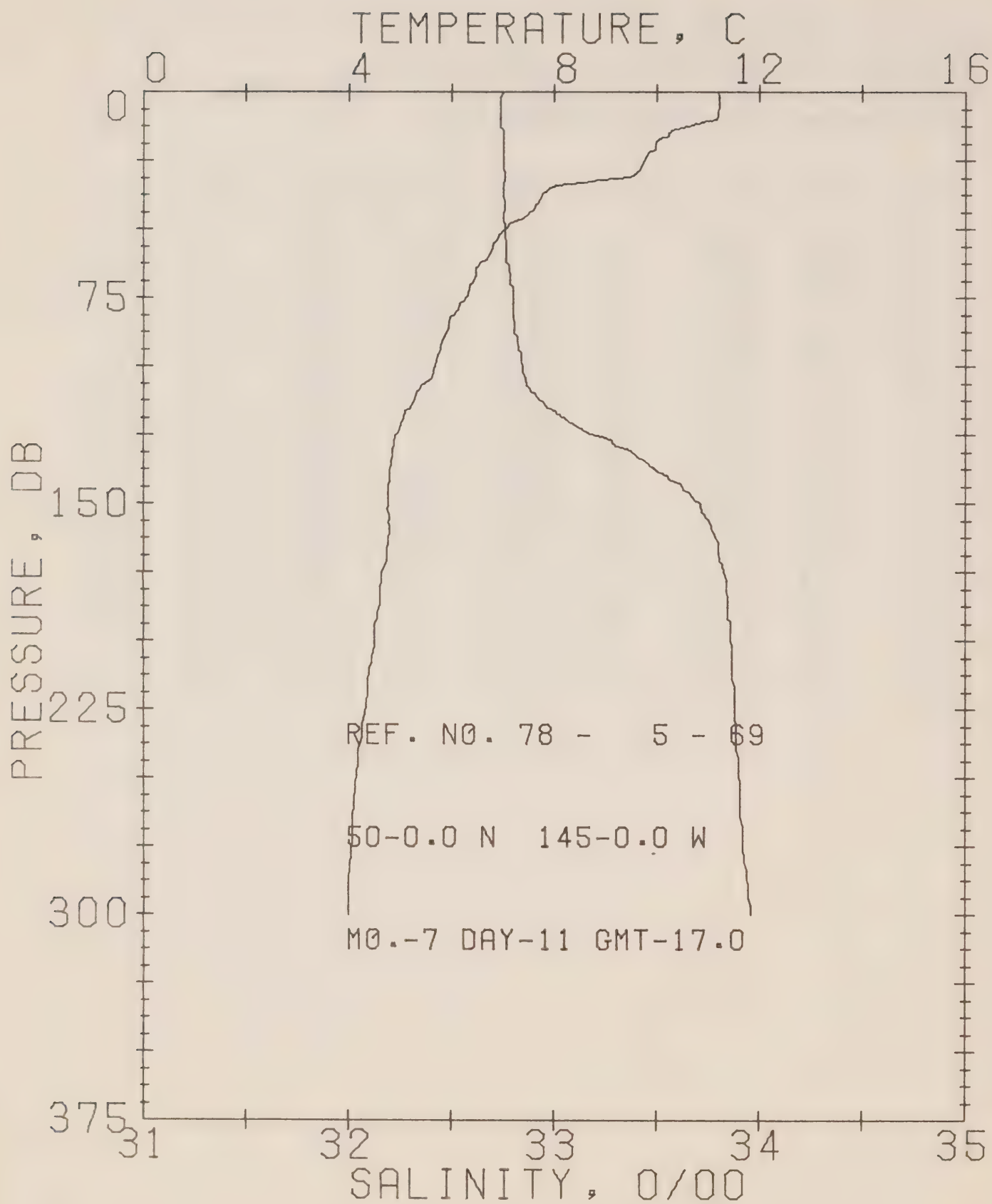
DATE 10/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 349 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 10.97 | 32.71 | 0 | 25.02 | 294.5 | .00 | .00 | 1491. |
| 10 | 10.95 | 32.71 | 10 | 25.03 | 294.4 | .29 | .02 | 1491. |
| 20 | 10.20 | 32.71 | 20 | 25.16 | 282.3 | .58 | .06 | 1489. |
| 30 | 9.87 | 32.72 | 30 | 25.22 | 276.5 | .86 | .13 | 1487. |
| 50 | 7.39 | 32.73 | 50 | 25.60 | 240.0 | 1.37 | .34 | 1478. |
| 75 | 6.40 | 32.77 | 75 | 25.77 | 224.7 | 1.95 | .70 | 1475. |
| 100 | 5.74 | 32.81 | 99 | 25.88 | 214.2 | 2.50 | 1.19 | 1473. |
| 125 | 4.99 | 33.21 | 124 | 26.29 | 175.7 | 3.00 | 1.76 | 1471. |
| 150 | 4.77 | 33.63 | 149 | 26.64 | 142.4 | 3.39 | 2.31 | 1471. |
| 175 | 4.69 | 33.77 | 174 | 26.76 | 131.3 | 3.73 | 2.87 | 1471. |
| 200 | 4.54 | 33.81 | 199 | 26.81 | 126.9 | 4.05 | 3.48 | 1471. |
| 225 | 4.29 | 33.84 | 223 | 26.86 | 122.4 | 4.36 | 4.16 | 1470. |
| 250 | 4.16 | 33.86 | 248 | 26.89 | 119.5 | 4.67 | 4.89 | 1470. |
| 300 | 3.99 | 33.92 | 298 | 26.95 | 113.8 | 5.25 | 6.52 | 1470. |
| 400 | 3.83 | 34.03 | 397 | 27.06 | 104.3 | 6.34 | 10.41 | 1471. |
| 500 | 3.73 | 34.13 | 496 | 27.15 | 96.9 | 7.34 | 15.00 | 1473. |
| 600 | 3.56 | 34.21 | 595 | 27.23 | 89.7 | 8.28 | 20.24 | 1474. |
| 800 | 3.21 | 34.30 | 793 | 27.33 | 80.9 | 9.97 | 32.32 | 1476. |
| 1000 | 2.90 | 34.38 | 990 | 27.42 | 73.1 | 11.51 | 46.42 | 1478. |
| 1200 | 2.63 | 34.44 | 1188 | 27.49 | 66.8 | 12.91 | 62.07 | 1480. |
| 1500 | 2.31 | 34.50 | 1484 | 27.57 | 60.3 | 14.80 | 87.95 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 69

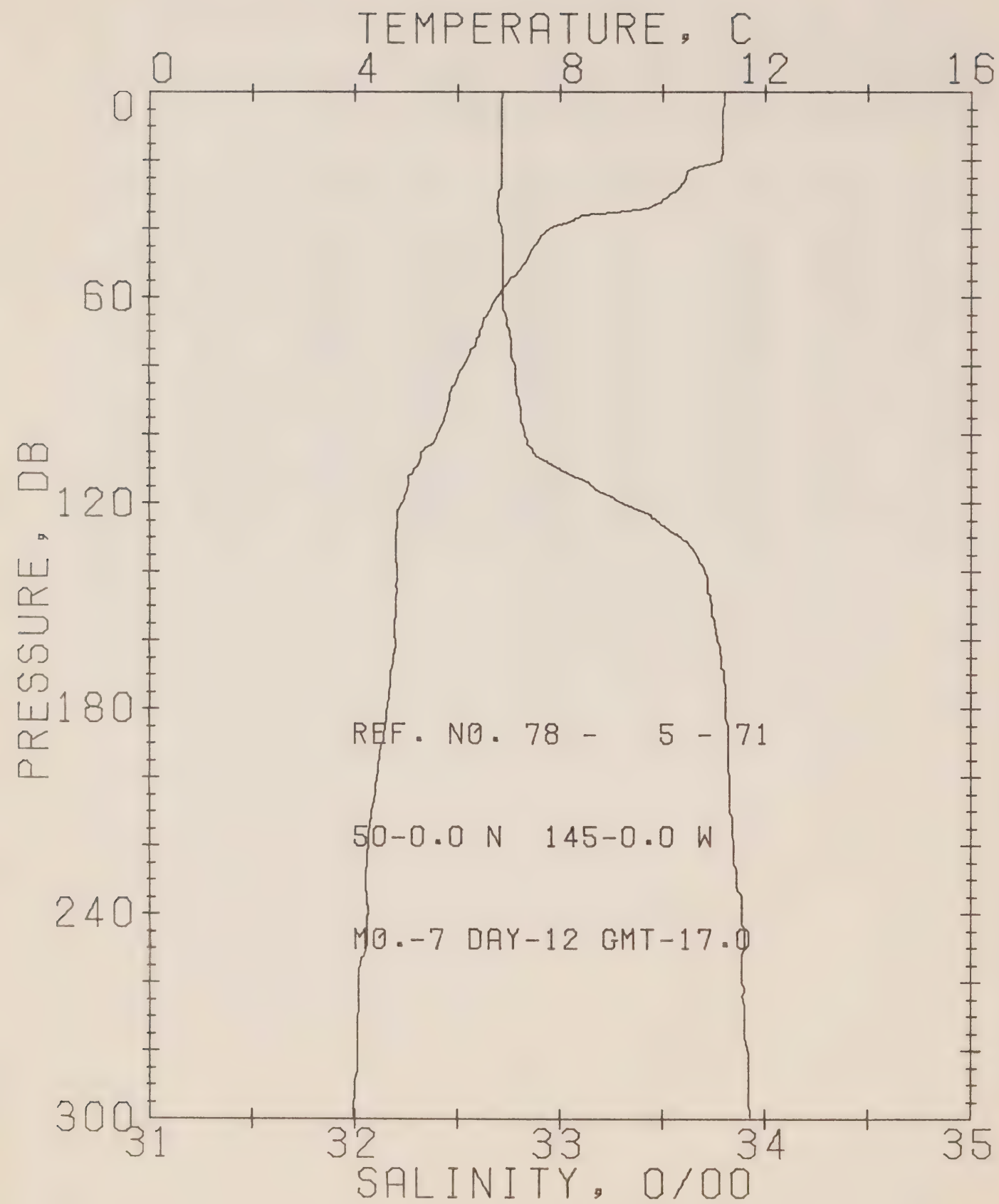
DATE 11/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 212 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 11.21 | 32.75 | 0 | 25.01 | 295.7 | .00 | .00 | 1492. |
| 10 | 11.18 | 32.74 | 10 | 25.01 | 296.1 | .30 | .02 | 1492. |
| 20 | 9.98 | 32.75 | 20 | 25.22 | 275.7 | .58 | .06 | 1488. |
| 30 | 9.58 | 32.76 | 30 | 25.30 | 269.0 | .85 | .13 | 1486. |
| 50 | 7.05 | 32.76 | 50 | 25.67 | 233.3 | 1.34 | .33 | 1477. |
| 75 | 6.29 | 32.80 | 75 | 25.80 | 221.1 | 1.91 | .69 | 1475. |
| 100 | 5.68 | 32.85 | 99 | 25.92 | 210.6 | 2.45 | 1.17 | 1475. |
| 125 | 4.95 | 33.17 | 124 | 26.25 | 178.7 | 2.94 | 1.73 | 1470. |
| 150 | 4.77 | 33.70 | 149 | 26.69 | 137.5 | 3.33 | 2.27 | 1471. |
| 175 | 4.67 | 33.83 | 174 | 26.81 | 126.7 | 3.66 | 2.82 | 1471. |
| 200 | 4.50 | 33.86 | 199 | 26.85 | 122.7 | 3.97 | 3.41 | 1471. |
| 225 | 4.34 | 33.88 | 223 | 26.88 | 119.8 | 4.27 | 4.07 | 1470. |
| 250 | 4.17 | 33.90 | 248 | 26.92 | 116.7 | 4.57 | 4.76 | 1470. |
| 300 | 4.00 | 33.96 | 298 | 26.98 | 110.9 | 5.14 | 6.38 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 71

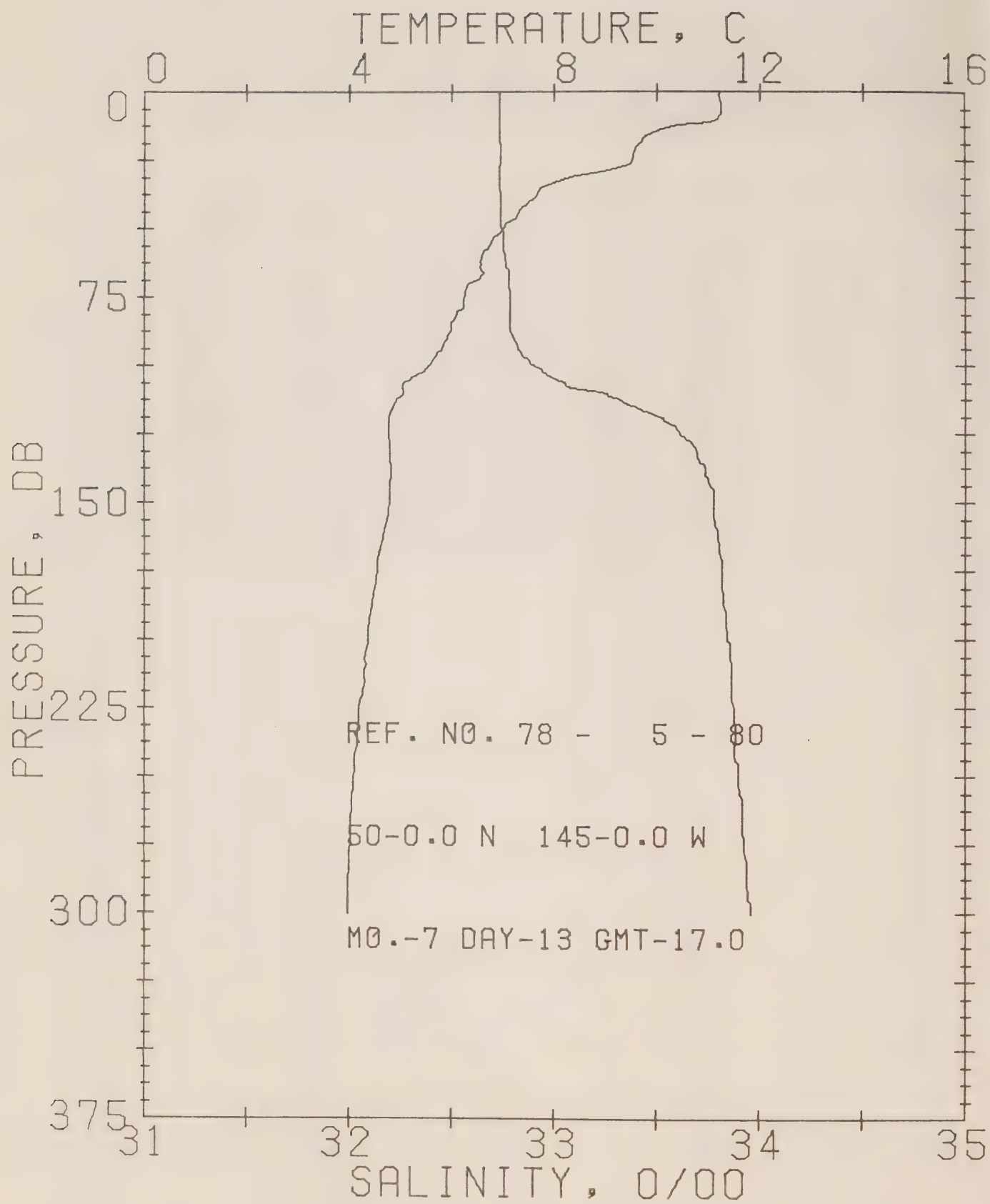
DATE 12/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 202 POINTS TAKEN FROM ANALOG TRACE

BISETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 11.20 | 32.72 | 0 | 24.99 | 297.7 | .00 | .00 | 1492. |
| 10 | 11.17 | 32.71 | 10 | 24.99 | 298.1 | .30 | .02 | 1492. |
| 20 | 11.14 | 32.71 | 20 | 24.99 | 297.9 | .60 | .06 | 1492. |
| 30 | 10.16 | 32.70 | 30 | 25.15 | 282.6 | .88 | .13 | 1489. |
| 50 | 7.31 | 32.72 | 50 | 25.61 | 239.7 | 1.39 | .34 | 1478. |
| 75 | 6.30 | 32.76 | 75 | 25.77 | 224.2 | 1.97 | .71 | 1475. |
| 100 | 5.62 | 32.83 | 99 | 25.91 | 211.4 | 2.52 | 1.19 | 1472. |
| 125 | 4.83 | 33.45 | 124 | 26.49 | 156.0 | 2.98 | 1.73 | 1470. |
| 150 | 4.81 | 33.74 | 149 | 26.72 | 135.0 | 3.34 | 2.22 | 1471. |
| 175 | 4.68 | 33.81 | 174 | 26.79 | 128.2 | 3.67 | 2.77 | 1471. |
| 200 | 4.44 | 33.82 | 199 | 26.83 | 124.9 | 3.98 | 3.37 | 1470. |
| 225 | 4.24 | 33.85 | 223 | 26.87 | 121.0 | 4.29 | 4.03 | 1470. |
| 250 | 4.23 | 33.90 | 248 | 26.91 | 117.3 | 4.59 | 4.75 | 1470. |
| 300 | 3.98 | 33.93 | 298 | 26.96 | 113.0 | 5.16 | 6.37 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 80

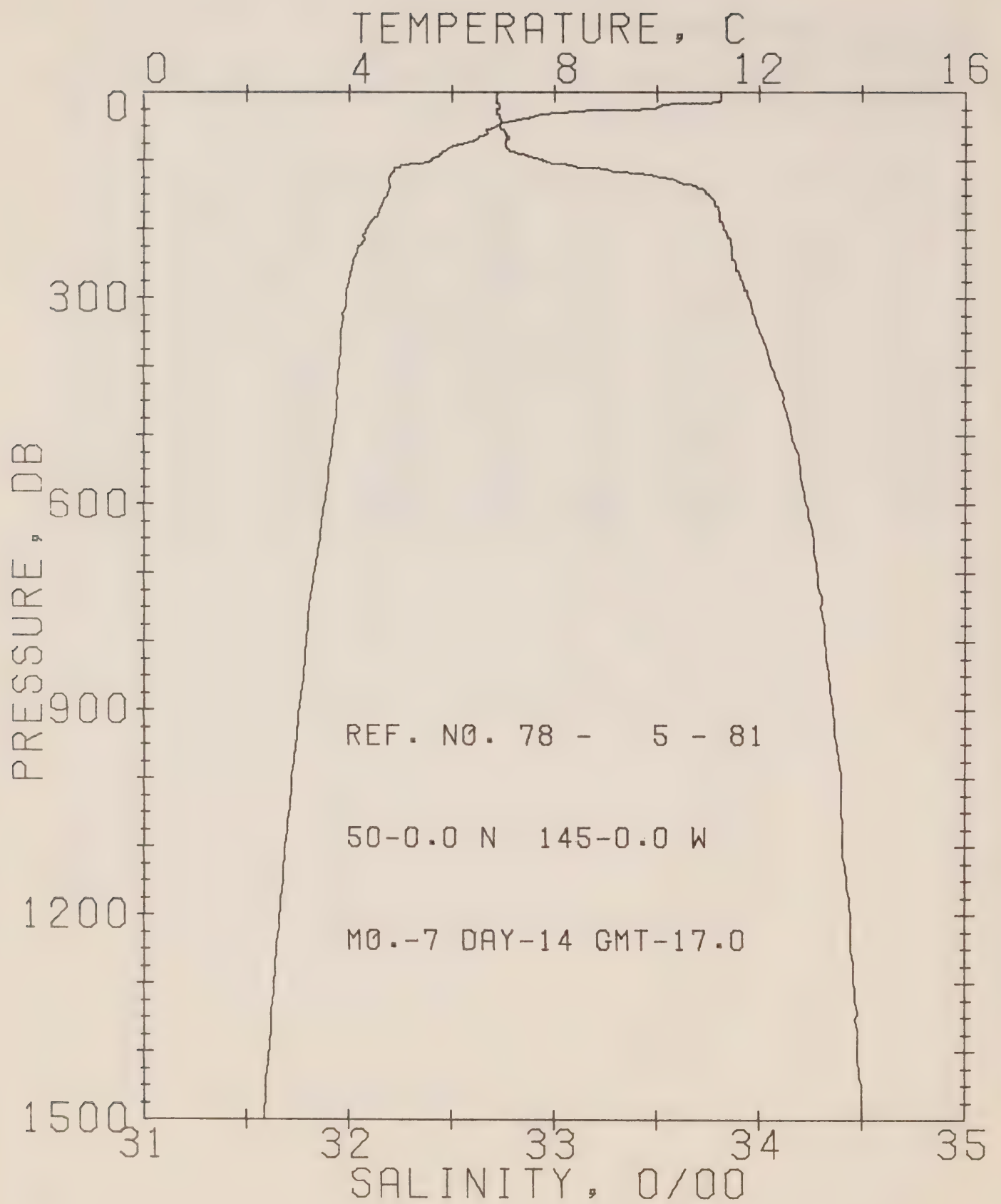
DATE 13/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 210 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 11.22 | 32.73 | 0 | 24.99 | 297.3 | .00 | .00 | 1492. |
| 10 | 11.18 | 32.73 | 10 | 25.00 | 296.9 | .30 | .02 | 1492. |
| 20 | 9.60 | 32.74 | 20 | 25.28 | 270.5 | .58 | .06 | 1486. |
| 30 | 8.67 | 32.73 | 30 | 25.42 | 257.6 | .84 | .13 | 1483. |
| 50 | 7.02 | 32.74 | 50 | 25.66 | 234.2 | 1.33 | .32 | 1477. |
| 75 | 6.26 | 32.79 | 75 | 25.80 | 221.5 | 1.90 | .68 | 1474. |
| 100 | 5.58 | 32.90 | 99 | 25.97 | 205.7 | 2.44 | 1.17 | 1472. |
| 125 | 4.78 | 33.61 | 124 | 26.62 | 143.6 | 2.87 | 1.65 | 1470. |
| 150 | 4.80 | 33.78 | 149 | 26.75 | 131.4 | 3.21 | 2.13 | 1471. |
| 175 | 4.55 | 33.82 | 174 | 26.81 | 126.1 | 3.53 | 2.66 | 1470. |
| 200 | 4.36 | 33.85 | 199 | 26.86 | 122.1 | 3.84 | 3.26 | 1470. |
| 225 | 4.21 | 33.87 | 223 | 26.89 | 118.8 | 4.14 | 3.91 | 1470. |
| 250 | 4.10 | 33.90 | 248 | 26.92 | 116.0 | 4.43 | 4.62 | 1470. |
| 300 | 3.97 | 33.96 | 298 | 26.99 | 110.6 | 5.00 | 6.21 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 81

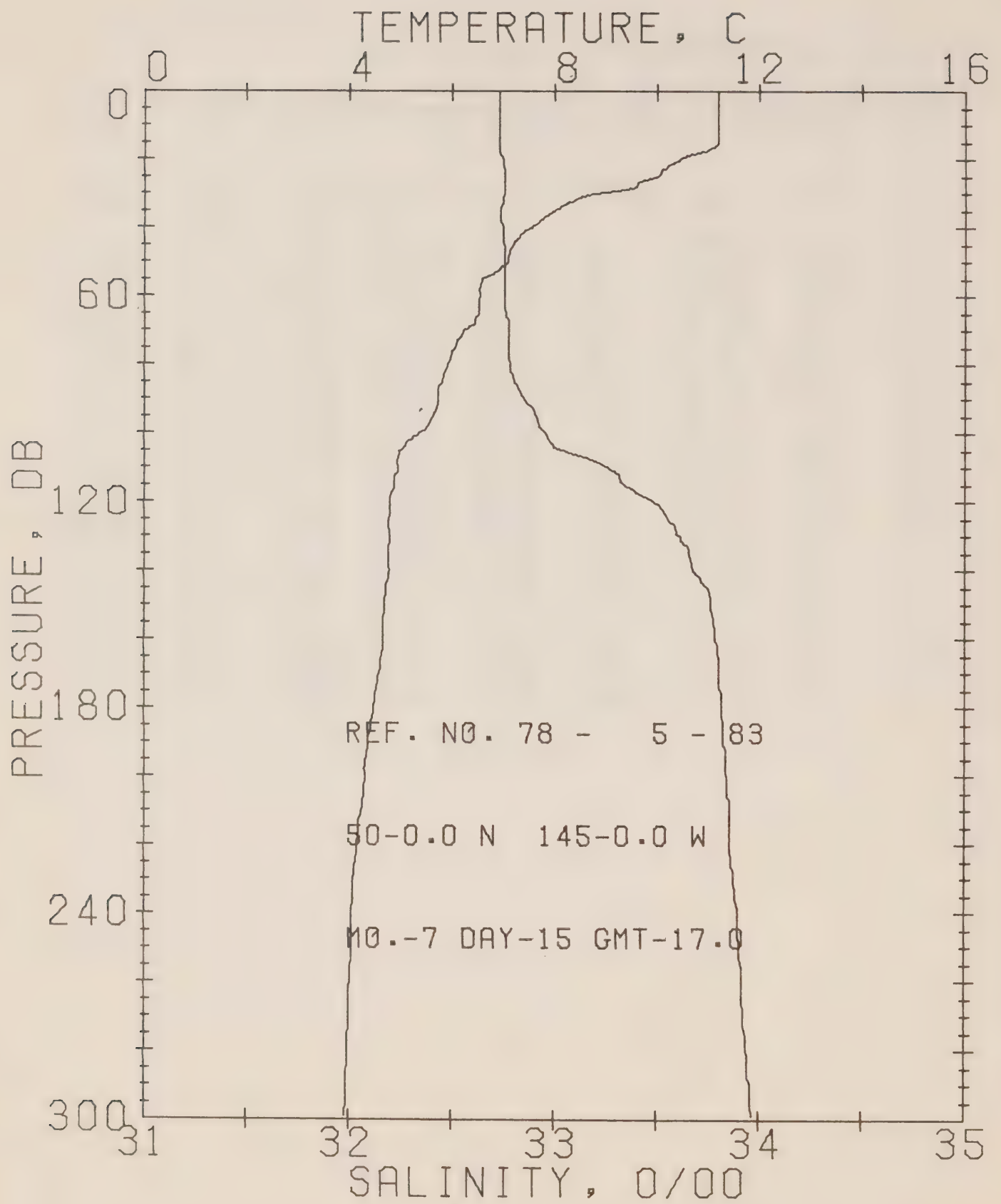
DATE 14/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 303 POINTS TAKEN FROM ANALOG TRACE

BISETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 11.25 | 32.73 | 0 | 24.99 | 297.8 | .00 | .00 | 1492. |
| 10 | 11.25 | 32.72 | 10 | 24.98 | 298.8 | .30 | .02 | 1492. |
| 20 | 10.06 | 32.73 | 20 | 25.19 | 278.6 | .59 | .06 | 1488. |
| 30 | 8.19 | 32.72 | 30 | 25.48 | 251.5 | .86 | .13 | 1481. |
| 50 | 6.86 | 32.73 | 50 | 25.67 | 233.1 | 1.34 | .32 | 1476. |
| 75 | 6.21 | 32.76 | 75 | 25.78 | 223.2 | 1.90 | .68 | 1474. |
| 100 | 5.58 | 32.94 | 99 | 26.00 | 202.2 | 2.44 | 1.16 | 1472. |
| 125 | 4.78 | 33.52 | 124 | 26.55 | 150.1 | 2.88 | 1.66 | 1476. |
| 150 | 4.75 | 33.75 | 149 | 26.74 | 133.2 | 3.23 | 2.15 | 1471. |
| 175 | 4.58 | 33.81 | 174 | 26.80 | 127.2 | 3.55 | 2.69 | 1471. |
| 200 | 4.35 | 33.83 | 199 | 26.84 | 123.4 | 3.87 | 3.29 | 1470. |
| 225 | 4.24 | 33.86 | 223 | 26.88 | 119.9 | 4.17 | 3.95 | 1470. |
| 250 | 4.07 | 33.89 | 248 | 26.92 | 116.7 | 4.47 | 4.66 | 1470. |
| 300 | 3.95 | 33.95 | 298 | 26.98 | 111.2 | 5.04 | 6.26 | 1470. |
| 400 | 3.81 | 34.05 | 397 | 27.07 | 103.0 | 6.11 | 10.07 | 1471. |
| 500 | 3.70 | 34.15 | 496 | 27.17 | 94.8 | 7.09 | 14.57 | 1473. |
| 600 | 3.53 | 34.22 | 595 | 27.24 | 88.6 | 8.01 | 19.70 | 1474. |
| 800 | 3.18 | 34.32 | 793 | 27.35 | 79.1 | 9.67 | 31.52 | 1476. |
| 1000 | 2.90 | 34.40 | 990 | 27.44 | 71.6 | 11.18 | 45.36 | 1478. |
| 1200 | 2.67 | 34.44 | 1188 | 27.49 | 67.1 | 12.58 | 61.01 | 1480. |
| 1500 | 2.35 | 34.50 | 1484 | 27.57 | 60.7 | 14.49 | 87.28 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 76- 5- 83

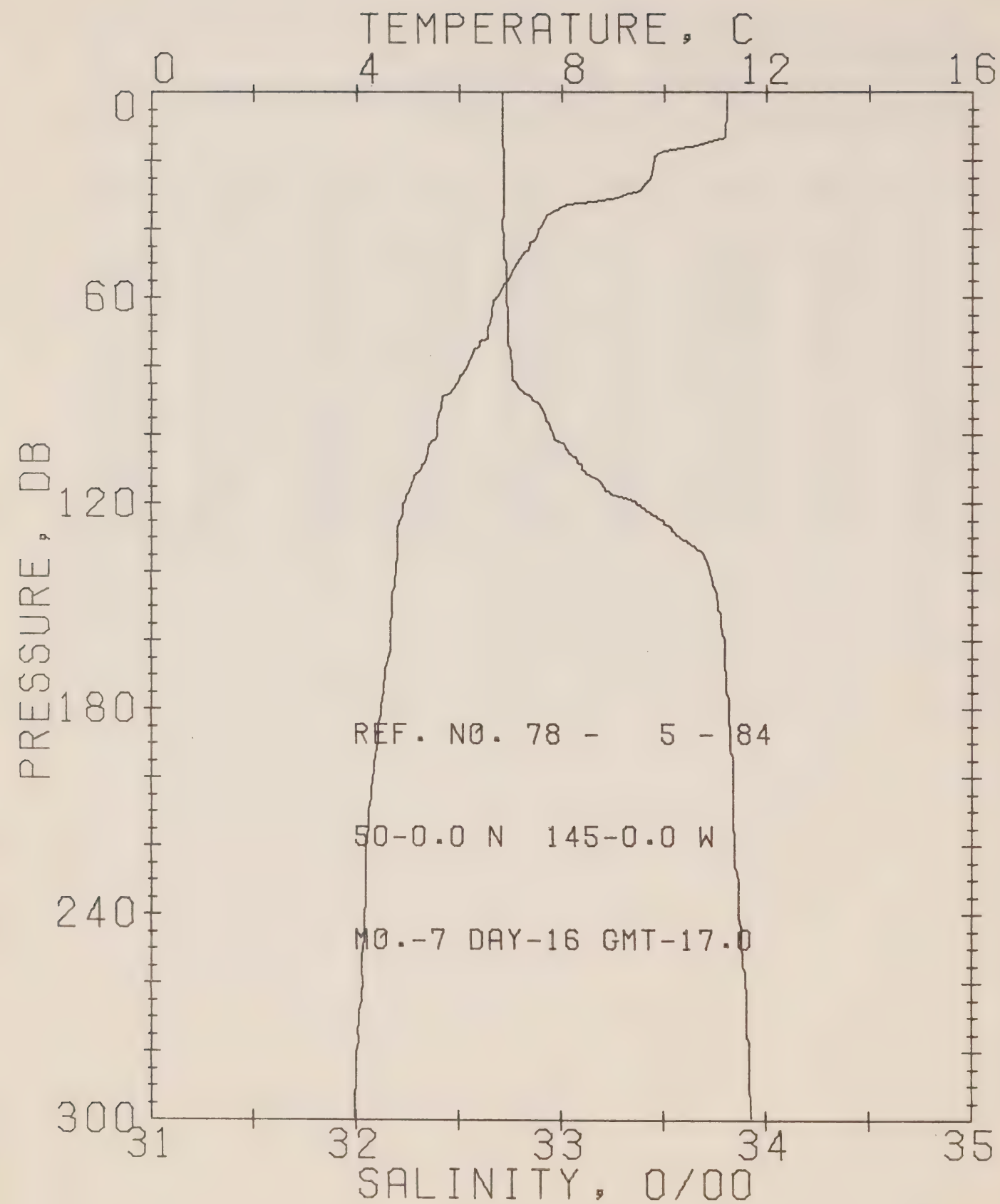
DATE 15/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 205 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 11.21 | 32.73 | 0 | 25.00 | 297.1 | .00 | .00 | 1492. |
| 10 | 11.21 | 32.73 | 10 | 25.00 | 297.3 | .30 | .02 | 1492. |
| 20 | 10.46 | 32.75 | 20 | 25.14 | 283.6 | .59 | .06 | 1489. |
| 30 | 8.89 | 32.76 | 30 | 25.41 | 258.5 | .87 | .13 | 1484. |
| 50 | 7.09 | 32.76 | 50 | 25.67 | 233.8 | 1.35 | .33 | 1477. |
| 75 | 6.07 | 32.78 | 75 | 25.82 | 219.9 | 1.92 | .69 | 1474. |
| 100 | 5.44 | 32.95 | 99 | 26.02 | 200.4 | 2.45 | 1.16 | 1472. |
| 125 | 4.78 | 33.55 | 124 | 26.58 | 148.1 | 2.87 | 1.65 | 1470. |
| 150 | 4.70 | 33.77 | 149 | 26.76 | 131.2 | 3.22 | 2.13 | 1471. |
| 175 | 4.54 | 33.81 | 174 | 26.81 | 126.7 | 3.54 | 2.67 | 1470. |
| 200 | 4.31 | 33.84 | 199 | 26.86 | 122.2 | 3.85 | 3.26 | 1470. |
| 225 | 4.14 | 33.87 | 223 | 26.89 | 118.6 | 4.16 | 3.91 | 1470. |
| 250 | 4.05 | 33.91 | 248 | 26.94 | 114.9 | 4.45 | 4.62 | 1470. |
| 300 | 3.93 | 33.97 | 298 | 27.00 | 109.6 | 5.01 | 6.19 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 84

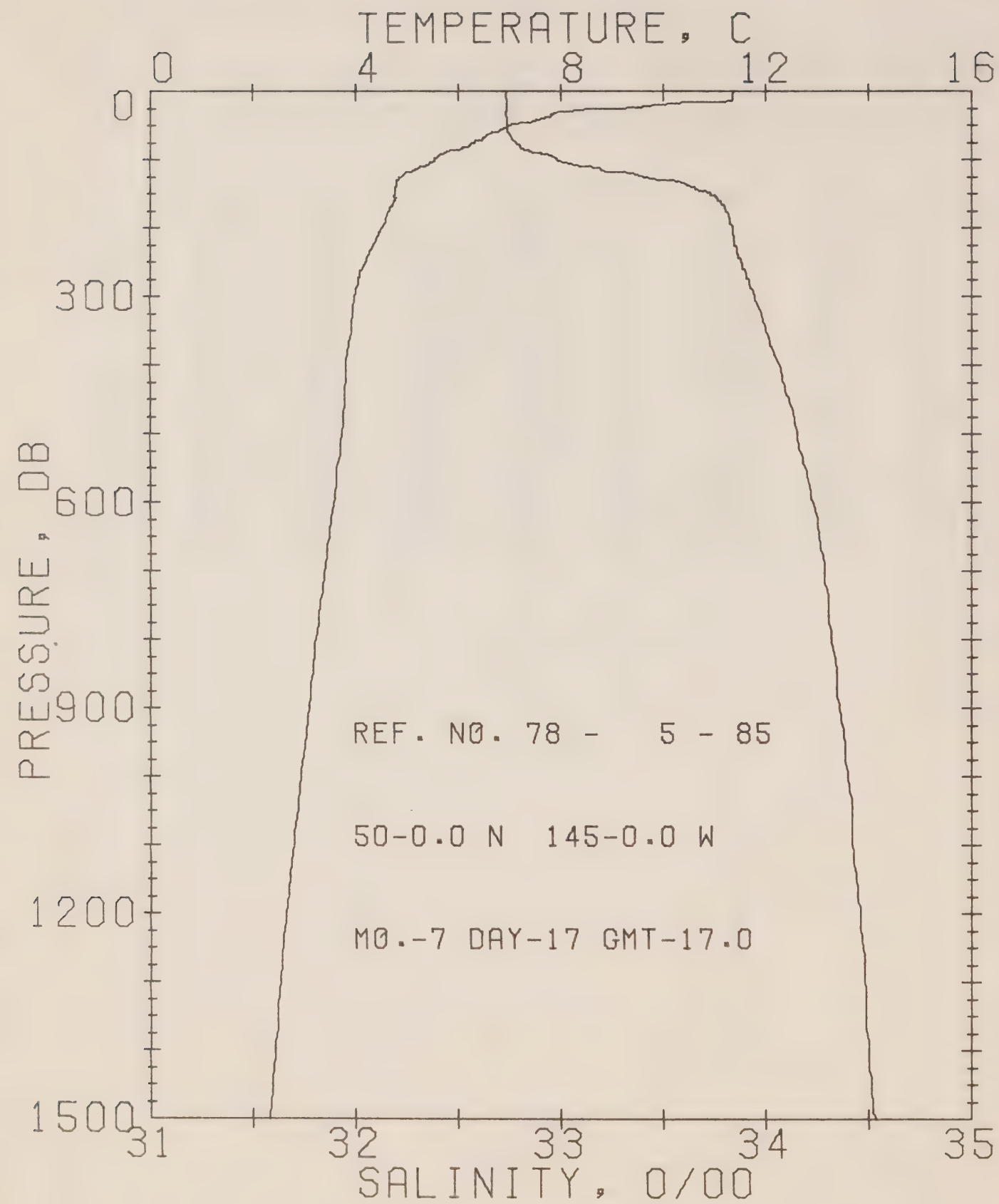
DATE 16/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 198 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 11.23 | 32.71 | 0 | 24.98 | 298.9 | .00 | .00 | 1492. |
| 10 | 11.21 | 32.71 | 10 | 24.98 | 298.8 | .30 | .02 | 1492. |
| 20 | 9.80 | 32.72 | 20 | 25.23 | 275.3 | .59 | .06 | 1487. |
| 30 | 9.26 | 32.72 | 30 | 25.32 | 267.1 | .86 | .13 | 1485. |
| 50 | 7.13 | 32.73 | 50 | 25.64 | 236.8 | 1.35 | .33 | 1477. |
| 75 | 6.34 | 32.75 | 75 | 25.76 | 225.7 | 1.93 | .70 | 1475. |
| 100 | 5.56 | 32.96 | 99 | 26.02 | 201.0 | 2.47 | 1.17 | 1472. |
| 125 | 4.86 | 33.48 | 124 | 26.51 | 154.7 | 2.92 | 1.69 | 1470. |
| 150 | 4.69 | 33.77 | 149 | 26.76 | 131.3 | 3.27 | 2.18 | 1471. |
| 175 | 4.54 | 33.81 | 174 | 26.81 | 126.6 | 3.59 | 2.71 | 1470. |
| 200 | 4.34 | 33.84 | 199 | 26.85 | 122.6 | 3.90 | 3.30 | 1470. |
| 225 | 4.19 | 33.85 | 223 | 26.88 | 120.5 | 4.20 | 3.96 | 1470. |
| 250 | 4.14 | 33.88 | 248 | 26.90 | 117.9 | 4.50 | 4.68 | 1470. |
| 300 | 3.97 | 33.93 | 298 | 26.96 | 112.8 | 5.08 | 6.29 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 85

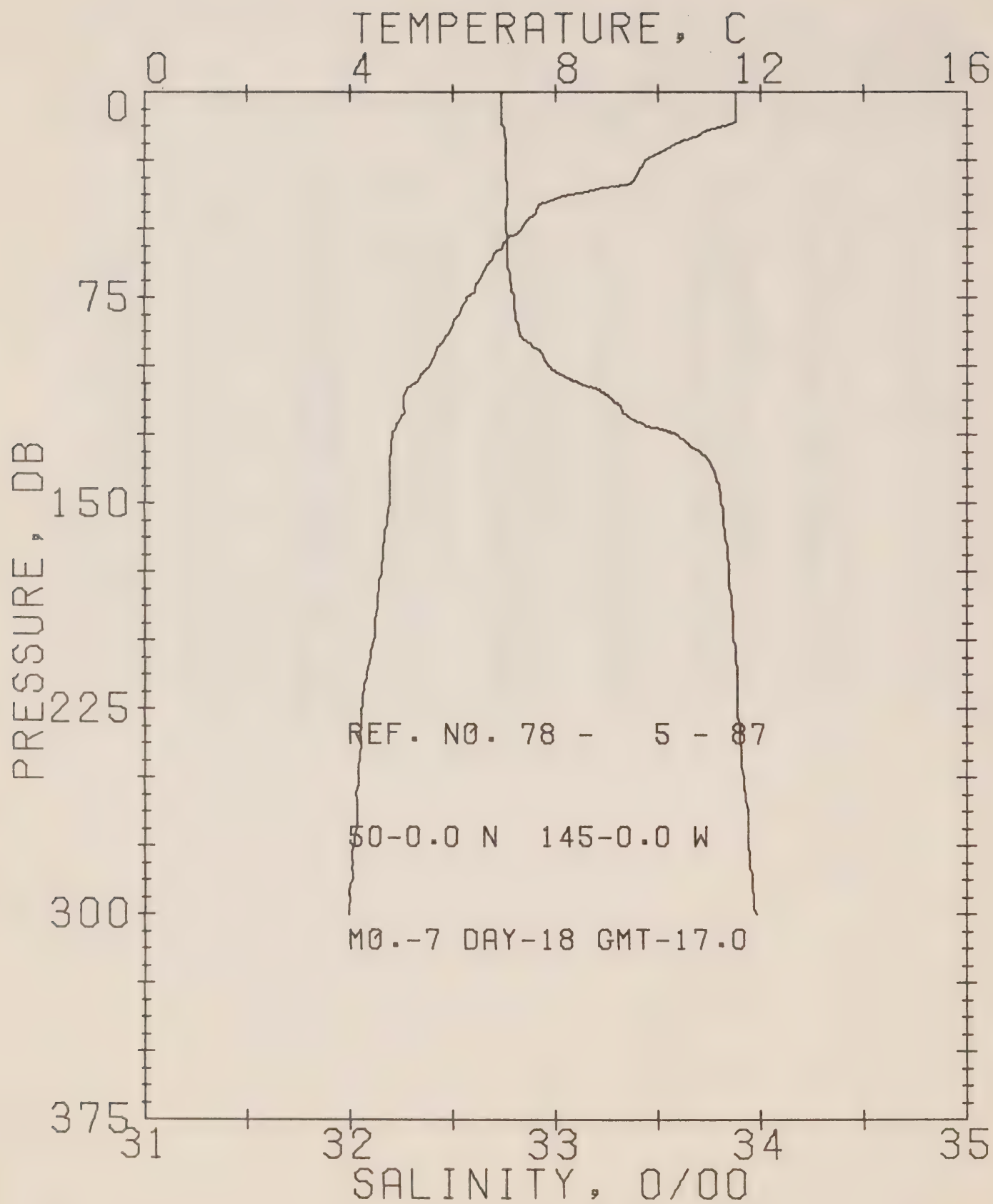
DATE 17/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 325 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 11.38 | 32.74 | 0 | 24.97 | 299.3 | .00 | .00 | 1492. |
| 10 | 11.36 | 32.73 | 10 | 24.97 | 299.9 | .30 | .02 | 1493. |
| 20 | 9.86 | 32.74 | 20 | 25.23 | 274.7 | .59 | .06 | 1487. |
| 30 | 8.15 | 32.74 | 30 | 25.50 | 249.4 | .85 | .13 | 1481. |
| 50 | 7.03 | 32.74 | 50 | 25.66 | 234.5 | 1.34 | .32 | 1477. |
| 75 | 6.33 | 32.78 | 75 | 25.78 | 223.3 | 1.91 | .69 | 1475. |
| 100 | 5.55 | 32.98 | 99 | 26.04 | 199.1 | 2.44 | 1.16 | 1472. |
| 125 | 4.91 | 33.39 | 124 | 26.44 | 161.4 | 2.90 | 1.68 | 1471. |
| 150 | 4.78 | 33.72 | 149 | 26.71 | 135.3 | 3.26 | 2.19 | 1471. |
| 175 | 4.66 | 33.81 | 174 | 26.79 | 128.1 | 3.59 | 2.73 | 1471. |
| 200 | 4.52 | 33.84 | 199 | 26.83 | 124.5 | 3.91 | 3.34 | 1471. |
| 225 | 4.36 | 33.85 | 223 | 26.86 | 122.2 | 4.21 | 4.00 | 1470. |
| 250 | 4.21 | 33.88 | 248 | 26.90 | 118.6 | 4.52 | 4.73 | 1470. |
| 300 | 3.98 | 33.95 | 298 | 26.98 | 111.5 | 5.09 | 6.34 | 1470. |
| 400 | 3.82 | 34.06 | 397 | 27.08 | 102.5 | 6.16 | 10.16 | 1471. |
| 500 | 3.75 | 34.15 | 496 | 27.16 | 95.8 | 7.15 | 14.70 | 1473. |
| 600 | 3.59 | 34.22 | 595 | 27.23 | 89.5 | 8.08 | 19.88 | 1474. |
| 800 | 3.23 | 34.32 | 793 | 27.34 | 79.7 | 9.75 | 31.80 | 1476. |
| 1000 | 2.95 | 34.40 | 990 | 27.43 | 72.2 | 11.27 | 45.70 | 1478. |
| 1200 | 2.66 | 34.46 | 1188 | 27.50 | 65.9 | 12.66 | 61.19 | 1480. |
| 1500 | 2.34 | 34.52 | 1484 | 27.58 | 59.1 | 14.53 | 86.92 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 87

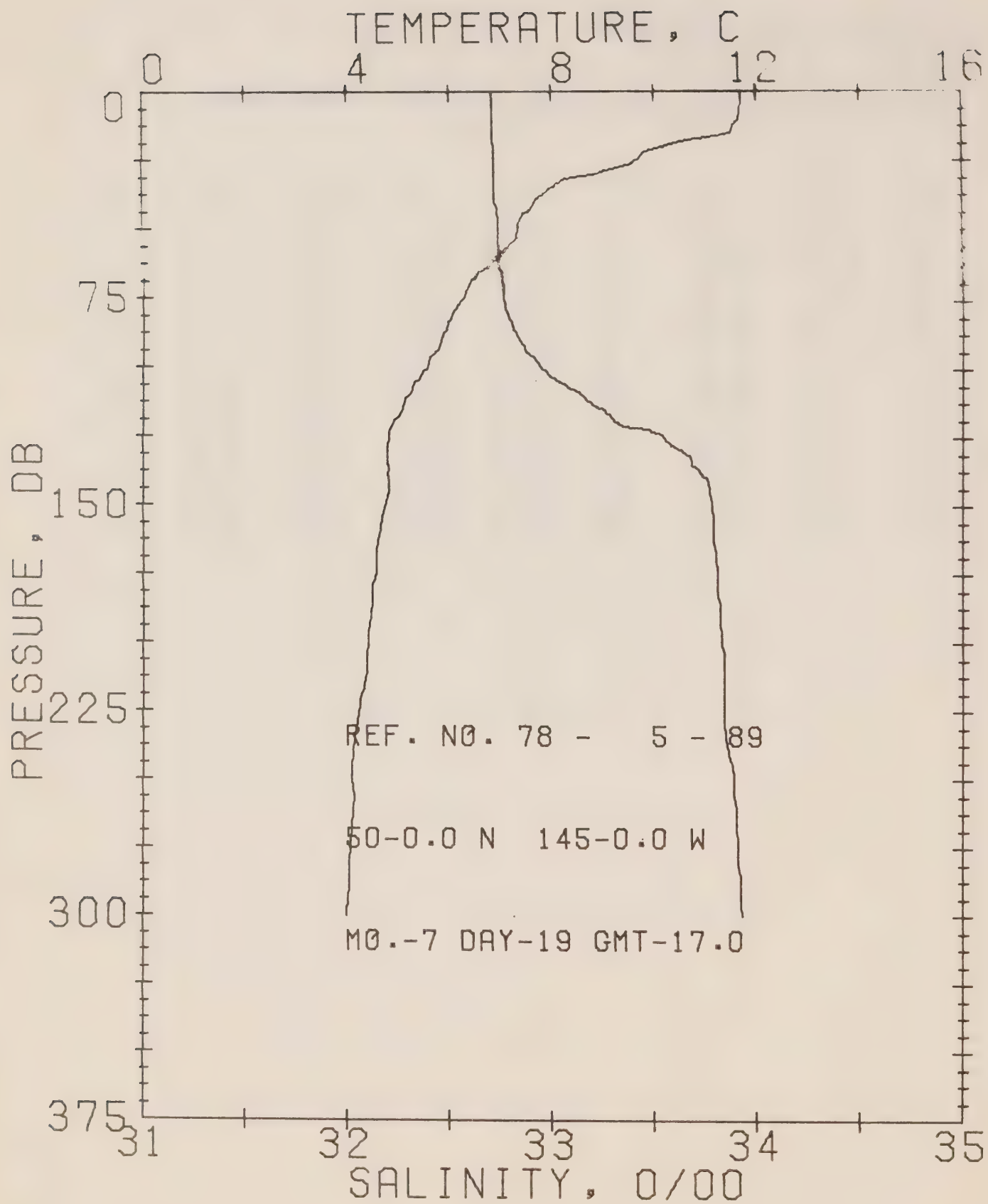
DATE 18/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 196 POINTS TAKEN FROM ANALOG TRACE

BISETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 11.53 | 32.74 | 0 | 24.95 | 301.9 | .00 | .00 | 1493. |
| 10 | 11.53 | 32.74 | 10 | 24.95 | 302.1 | .30 | .02 | 1493. |
| 20 | 10.28 | 32.76 | 20 | 25.18 | 279.9 | .59 | .06 | 1489. |
| 30 | 9.60 | 32.76 | 30 | 25.29 | 269.2 | .87 | .13 | 1487. |
| 50 | 7.34 | 32.76 | 50 | 25.63 | 237.1 | 1.36 | .33 | 1478. |
| 75 | 6.32 | 32.80 | 75 | 25.80 | 221.4 | 1.94 | .69 | 1475. |
| 100 | 5.56 | 32.96 | 99 | 26.02 | 200.6 | 2.47 | 1.17 | 1472. |
| 125 | 4.84 | 33.56 | 124 | 26.57 | 148.3 | 2.91 | 1.67 | 1470. |
| 150 | 4.77 | 33.81 | 149 | 26.78 | 129.0 | 3.24 | 2.14 | 1471. |
| 175 | 4.60 | 33.85 | 174 | 26.83 | 124.4 | 3.56 | 2.66 | 1471. |
| 200 | 4.47 | 33.87 | 199 | 26.86 | 121.7 | 3.87 | 3.25 | 1471. |
| 225 | 4.23 | 33.89 | 223 | 26.90 | 117.9 | 4.17 | 3.90 | 1470. |
| 250 | 4.16 | 33.92 | 248 | 26.93 | 115.5 | 4.46 | 4.60 | 1470. |
| 300 | 3.97 | 33.97 | 298 | 26.99 | 109.9 | 5.02 | 6.18 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 89

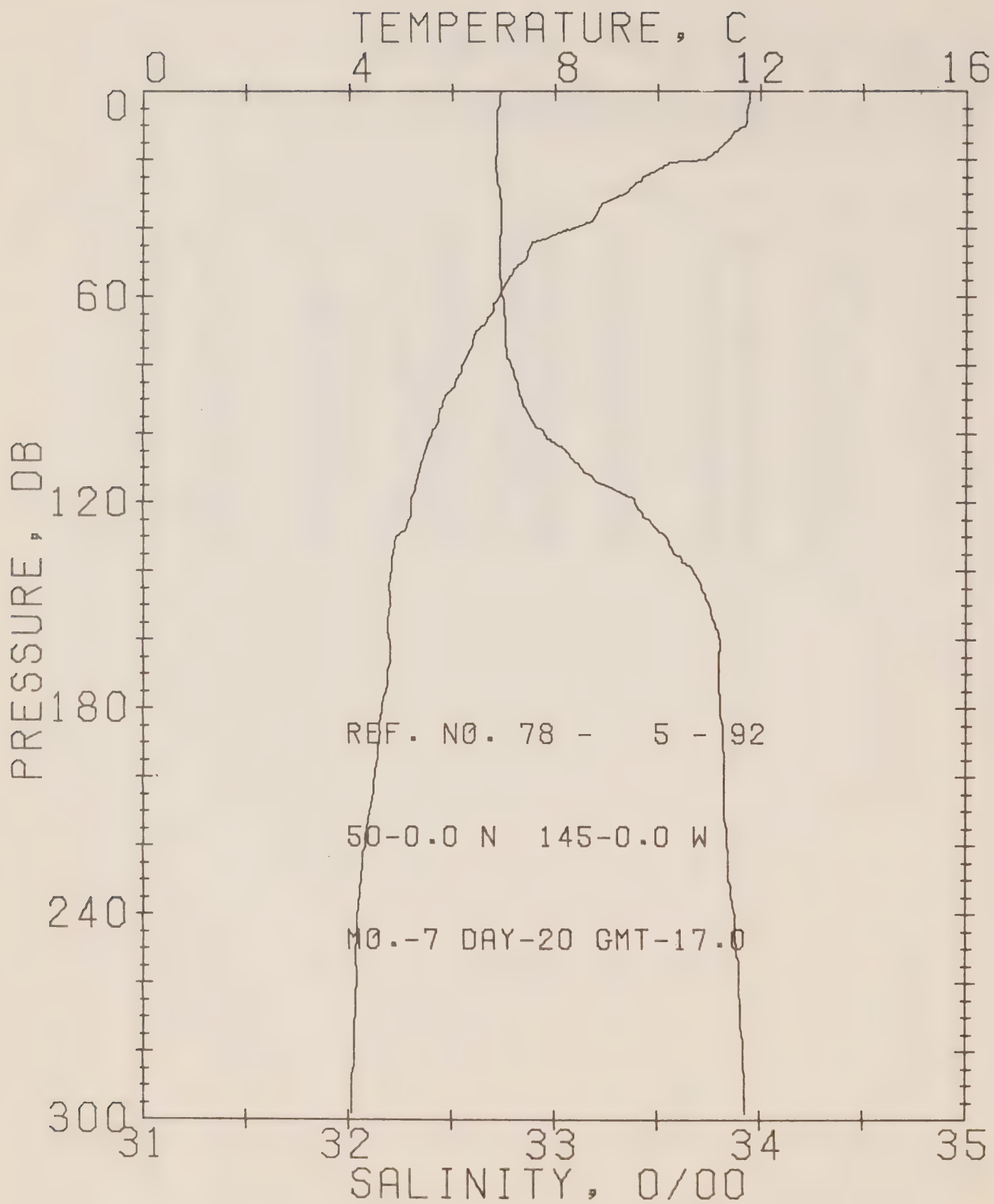
DATE 19/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 159 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 11.70 | 32.71 | 0 | 24.89 | 307.1 | .00 | .00 | 1494. |
| 10 | 11.65 | 32.71 | 10 | 24.90 | 306.4 | .31 | .02 | 1494. |
| 20 | 10.18 | 32.72 | 20 | 25.17 | 281.3 | .61 | .06 | 1488. |
| 30 | 8.86 | 32.72 | 30 | 25.38 | 261.1 | .88 | .13 | 1484. |
| 50 | 7.32 | 32.74 | 50 | 25.62 | 238.3 | 1.37 | .33 | 1478. |
| 75 | 6.24 | 32.76 | 75 | 25.78 | 223.3 | 1.94 | .70 | 1474. |
| 100 | 5.56 | 32.94 | 99 | 26.01 | 202.0 | 2.48 | 1.17 | 1472. |
| 125 | 4.81 | 33.53 | 124 | 26.56 | 149.9 | 2.93 | 1.68 | 1470. |
| 150 | 4.76 | 33.78 | 149 | 26.76 | 131.1 | 3.27 | 2.17 | 1471. |
| 175 | 4.55 | 33.81 | 174 | 26.81 | 126.8 | 3.59 | 2.70 | 1470. |
| 200 | 4.40 | 33.83 | 199 | 26.84 | 123.9 | 3.91 | 3.30 | 1470. |
| 225 | 4.22 | 33.84 | 223 | 26.86 | 121.6 | 4.22 | 3.96 | 1470. |
| 250 | 4.08 | 33.89 | 248 | 26.92 | 116.5 | 4.51 | 4.69 | 1470. |
| 300 | 3.98 | 33.92 | 298 | 26.96 | 113.4 | 5.09 | 6.30 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 92

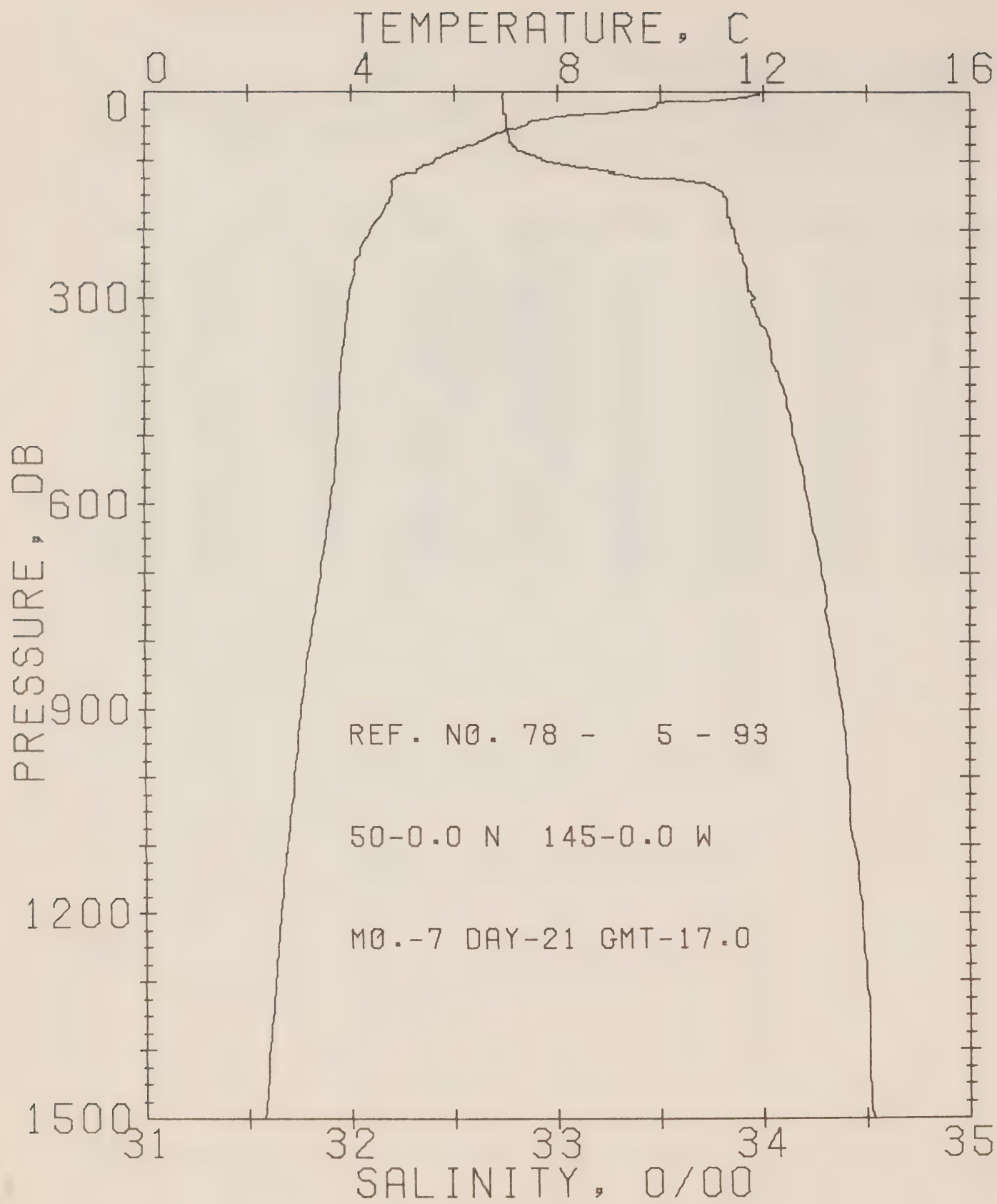
DATE 20/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 201 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 11.78 | 32.74 | 0 | 24.90 | 306.3 | .00 | .00 | 1494. |
| 10 | 11.72 | 32.72 | 10 | 24.89 | 306.9 | .31 | .02 | 1494. |
| 20 | 10.94 | 32.71 | 20 | 25.03 | 294.4 | .61 | .06 | 1491. |
| 30 | 9.37 | 32.73 | 30 | 25.31 | 268.0 | .88 | .13 | 1486. |
| 50 | 7.38 | 32.73 | 50 | 25.60 | 239.9 | 1.39 | .34 | 1478. |
| 75 | 6.38 | 32.76 | 75 | 25.76 | 225.0 | 1.97 | .70 | 1475. |
| 100 | 5.61 | 32.94 | 99 | 26.00 | 202.6 | 2.50 | 1.18 | 1472. |
| 125 | 5.18 | 33.44 | 124 | 26.44 | 161.2 | 2.96 | 1.70 | 1472. |
| 150 | 4.79 | 33.74 | 149 | 26.72 | 134.4 | 3.32 | 2.21 | 1471. |
| 175 | 4.73 | 33.80 | 174 | 26.78 | 129.5 | 3.65 | 2.75 | 1471. |
| 200 | 4.51 | 33.83 | 199 | 26.83 | 125.1 | 3.96 | 3.35 | 1471. |
| 225 | 4.28 | 33.85 | 223 | 26.87 | 121.4 | 4.27 | 4.02 | 1470. |
| 250 | 4.15 | 33.88 | 248 | 26.91 | 117.7 | 4.57 | 4.75 | 1470. |
| 300 | 4.04 | 33.93 | 298 | 26.95 | 113.6 | 5.15 | 6.36 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 93

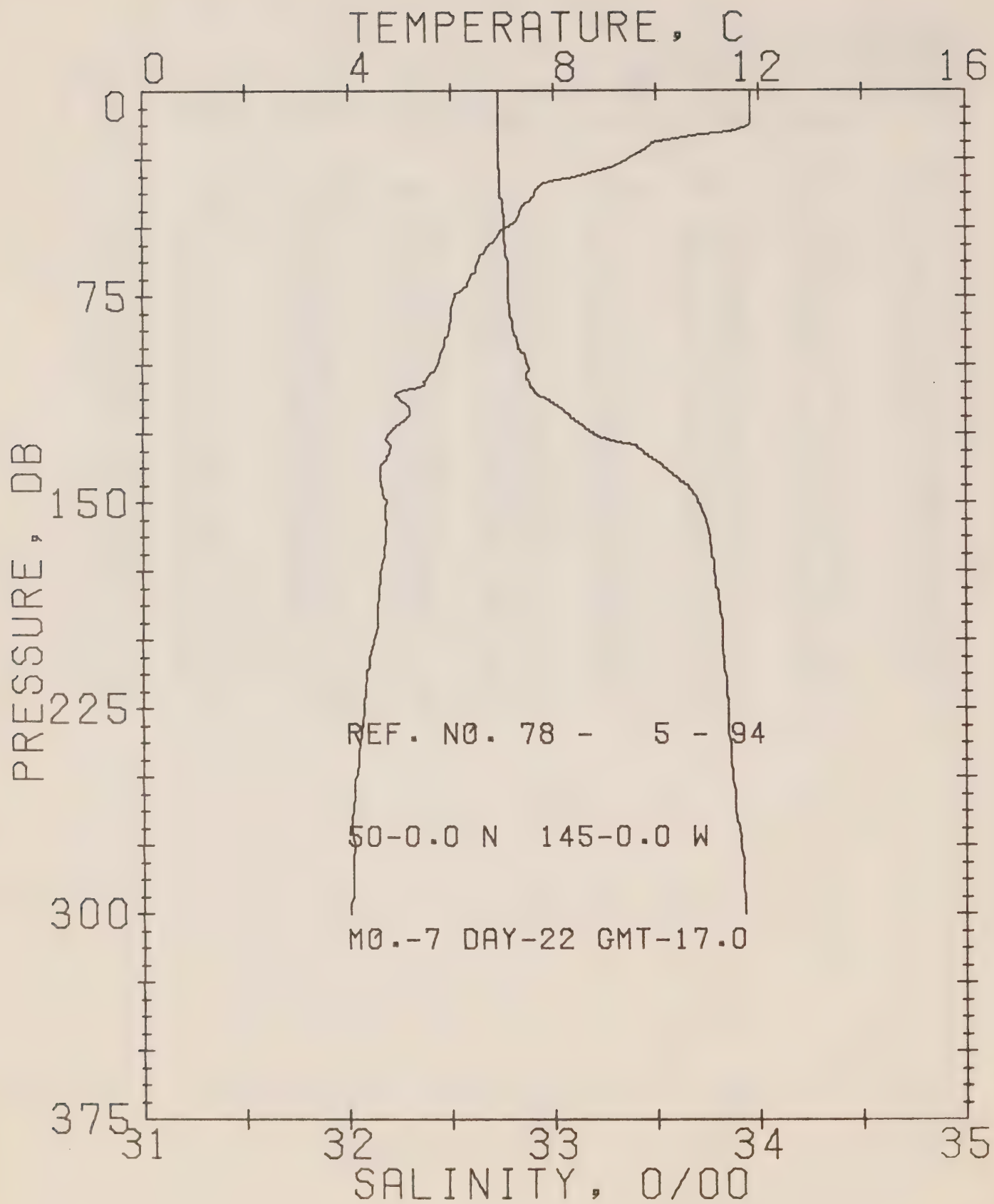
DATE 21/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 313 POINTS TAKEN FROM ANALOG TRACE

BISETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 11.91 | 32.74 | 0 | 24.88 | 308.6 | .00 | .00 | 1494. |
| 10 | 11.43 | 32.73 | 10 | 24.95 | 301.2 | .31 | .02 | 1493. |
| 20 | 9.91 | 32.74 | 20 | 25.23 | 275.5 | .59 | .06 | 1488. |
| 30 | 9.13 | 32.74 | 30 | 25.35 | 263.7 | .86 | .13 | 1485. |
| 50 | 7.32 | 32.75 | 50 | 25.63 | 237.6 | 1.35 | .33 | 1478. |
| 75 | 6.44 | 32.77 | 75 | 25.76 | 225.0 | 1.93 | .69 | 1475. |
| 100 | 5.63 | 32.94 | 99 | 25.99 | 203.4 | 2.46 | 1.17 | 1472. |
| 125 | 4.86 | 33.40 | 124 | 26.45 | 160.2 | 2.92 | 1.69 | 1470. |
| 150 | 4.79 | 33.81 | 149 | 26.78 | 129.1 | 3.27 | 2.17 | 1471. |
| 175 | 4.62 | 33.83 | 174 | 26.81 | 126.0 | 3.58 | 2.70 | 1471. |
| 200 | 4.39 | 33.85 | 199 | 26.86 | 122.1 | 3.90 | 3.29 | 1470. |
| 225 | 4.21 | 33.88 | 223 | 26.90 | 118.4 | 4.20 | 3.95 | 1470. |
| 250 | 4.07 | 33.90 | 248 | 26.93 | 115.4 | 4.49 | 4.65 | 1470. |
| 300 | 3.97 | 33.95 | 298 | 26.98 | 111.0 | 5.06 | 6.25 | 1470. |
| 400 | 3.82 | 34.05 | 397 | 27.07 | 103.3 | 6.13 | 10.06 | 1471. |
| 500 | 3.75 | 34.14 | 496 | 27.15 | 96.5 | 7.12 | 14.60 | 1473. |
| 600 | 3.61 | 34.21 | 595 | 27.22 | 90.1 | 8.05 | 19.81 | 1474. |
| 800 | 3.21 | 34.32 | 793 | 27.35 | 79.1 | 9.74 | 31.80 | 1476. |
| 1000 | 2.90 | 34.41 | 990 | 27.45 | 70.8 | 11.22 | 45.38 | 1476. |
| 1200 | 2.64 | 34.48 | 1188 | 27.52 | 63.9 | 12.57 | 60.55 | 1480. |
| 1500 | 2.32 | 34.52 | 1484 | 27.58 | 58.9 | 14.41 | 85.77 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 94

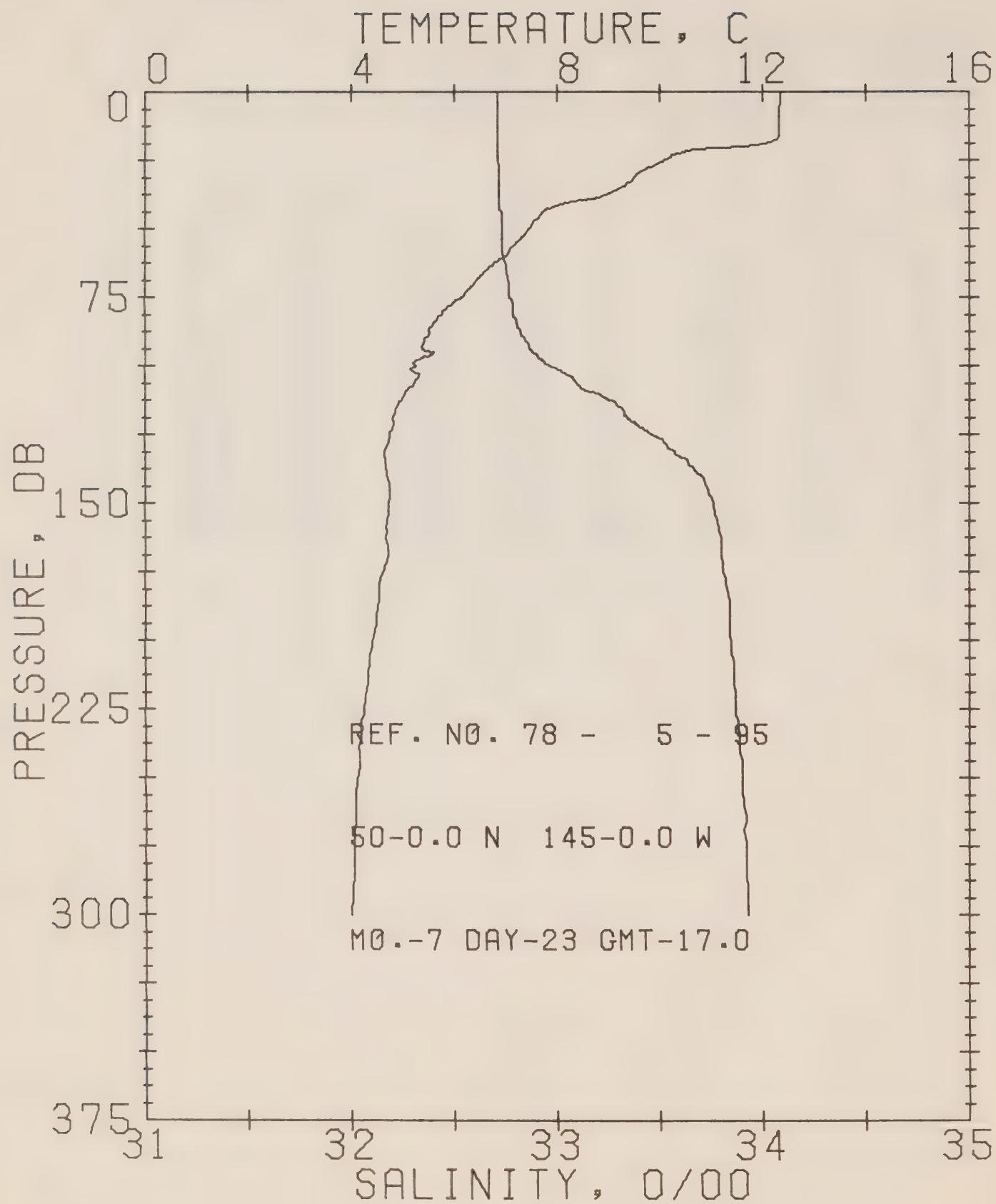
DATE 22/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 194 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 11.85 | 32.73 | 0 | 24.88 | 308.2 | .00 | .00 | 1494. |
| 10 | 11.84 | 32.73 | 10 | 24.88 | 308.3 | .31 | .02 | 1494. |
| 20 | 9.88 | 32.73 | 20 | 25.22 | 275.6 | .60 | .06 | 1487. |
| 30 | 8.73 | 32.74 | 30 | 25.42 | 257.7 | .87 | .13 | 1483. |
| 50 | 7.07 | 32.76 | 50 | 25.67 | 233.6 | 1.36 | .33 | 1477. |
| 75 | 6.08 | 32.78 | 75 | 25.81 | 220.1 | 1.92 | .69 | 1474. |
| 100 | 5.75 | 32.87 | 99 | 25.93 | 209.6 | 2.46 | 1.17 | 1473. |
| 125 | 4.82 | 33.17 | 124 | 26.27 | 176.8 | 2.95 | 1.73 | 1470. |
| 150 | 4.75 | 33.70 | 149 | 26.70 | 136.9 | 3.33 | 2.25 | 1471. |
| 175 | 4.64 | 33.78 | 174 | 26.77 | 130.0 | 3.66 | 2.80 | 1471. |
| 200 | 4.51 | 33.82 | 199 | 26.82 | 125.8 | 3.98 | 3.41 | 1471. |
| 225 | 4.30 | 33.85 | 223 | 26.86 | 121.6 | 4.29 | 4.08 | 1470. |
| 250 | 4.16 | 33.87 | 248 | 26.89 | 118.8 | 4.59 | 4.81 | 1470. |
| 300 | 4.02 | 33.93 | 298 | 26.96 | 113.4 | 5.17 | 6.43 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5- 95

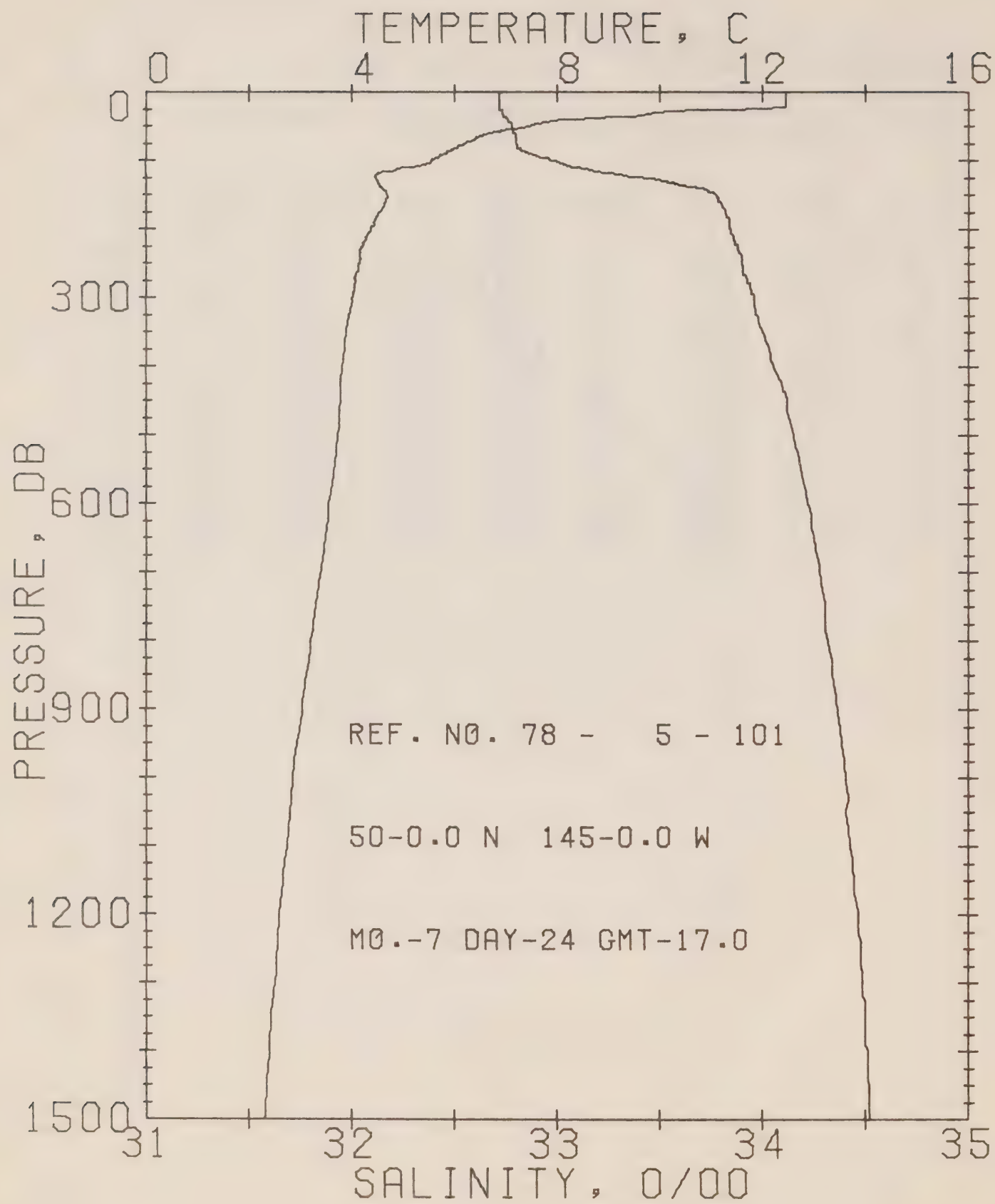
DATE 23/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 184 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 12.34 | 32.71 | 0 | 24.77 | 318.5 | .00 | .00 | 1496. |
| 10 | 12.33 | 32.71 | 10 | 24.77 | 318.5 | .32 | .02 | 1496. |
| 20 | 11.70 | 32.71 | 20 | 24.89 | 307.5 | .64 | .06 | 1494. |
| 30 | 9.55 | 32.72 | 30 | 25.27 | 271.6 | .92 | .14 | 1486. |
| 50 | 7.45 | 32.73 | 50 | 25.59 | 240.8 | 1.43 | .34 | 1479. |
| 75 | 6.16 | 32.77 | 75 | 25.80 | 221.8 | 2.01 | .71 | 1474. |
| 100 | 5.21 | 32.95 | 99 | 26.05 | 197.8 | 2.53 | 1.18 | 1471. |
| 125 | 4.76 | 33.44 | 124 | 26.49 | 155.9 | 2.97 | 1.68 | 1470. |
| 150 | 4.73 | 33.76 | 149 | 26.74 | 132.7 | 3.33 | 2.17 | 1471. |
| 175 | 4.63 | 33.81 | 174 | 26.80 | 127.6 | 3.65 | 2.71 | 1471. |
| 200 | 4.43 | 33.84 | 199 | 26.84 | 123.4 | 3.96 | 3.31 | 1470. |
| 225 | 4.25 | 33.87 | 223 | 26.89 | 119.6 | 4.27 | 3.96 | 1470. |
| 250 | 4.12 | 33.90 | 248 | 26.92 | 116.2 | 4.56 | 4.68 | 1470. |
| 300 | 4.00 | 33.93 | 298 | 26.96 | 113.1 | 5.13 | 6.28 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-101

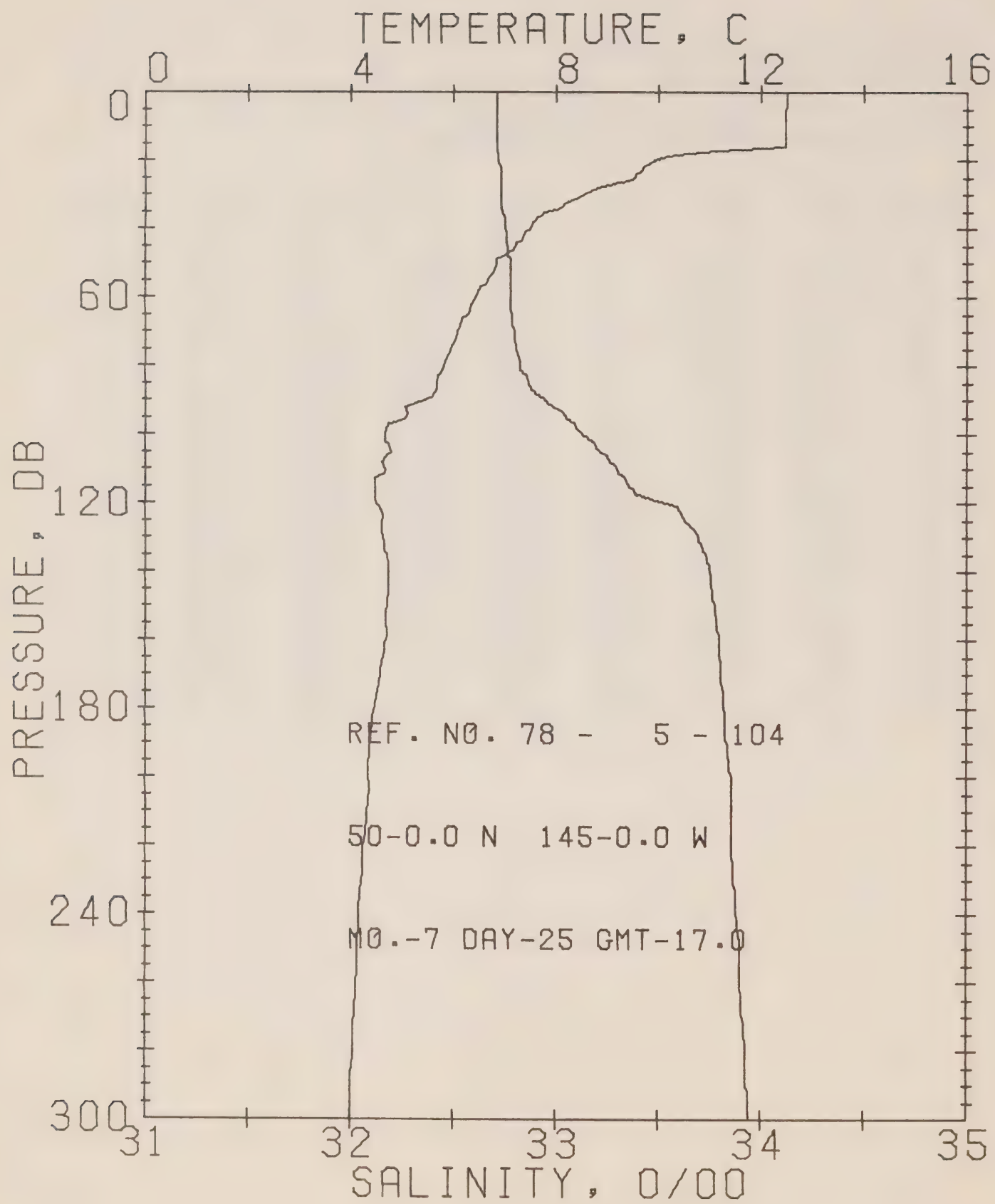
DATE 24/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 321 POINTS TAKEN FROM ANALOG TRACE

BISETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 12.46 | 32.73 | 0 | 24.76 | 319.2 | .00 | .00 | 1496. |
| 10 | 12.46 | 32.72 | 10 | 24.76 | 320.1 | .32 | .02 | 1496. |
| 20 | 12.46 | 32.72 | 20 | 24.76 | 320.3 | .64 | .07 | 1496. |
| 30 | 10.02 | 32.73 | 30 | 25.20 | 278.0 | .94 | .14 | 1488. |
| 50 | 7.45 | 32.78 | 50 | 25.63 | 237.0 | 1.45 | .35 | 1479. |
| 75 | 6.21 | 32.80 | 75 | 25.81 | 220.1 | 2.01 | .71 | 1474. |
| 100 | 5.56 | 32.98 | 99 | 26.03 | 199.5 | 2.54 | 1.18 | 1472. |
| 125 | 4.47 | 33.41 | 124 | 26.50 | 155.2 | 3.00 | 1.69 | 1469. |
| 150 | 4.70 | 33.77 | 149 | 26.76 | 131.2 | 3.35 | 2.19 | 1471. |
| 175 | 4.56 | 33.82 | 174 | 26.81 | 126.1 | 3.67 | 2.72 | 1470. |
| 200 | 4.37 | 33.84 | 199 | 26.85 | 122.7 | 3.98 | 3.31 | 1470. |
| 225 | 4.23 | 33.88 | 223 | 26.90 | 118.6 | 4.28 | 3.97 | 1470. |
| 250 | 4.16 | 33.90 | 248 | 26.92 | 116.6 | 4.58 | 4.67 | 1470. |
| 300 | 4.02 | 33.96 | 298 | 26.98 | 111.1 | 5.15 | 6.27 | 1470. |
| 400 | 3.82 | 34.05 | 397 | 27.07 | 103.3 | 6.22 | 10.10 | 1471. |
| 500 | 3.74 | 34.15 | 496 | 27.16 | 95.8 | 7.21 | 14.62 | 1473. |
| 600 | 3.58 | 34.22 | 595 | 27.23 | 89.7 | 8.14 | 19.82 | 1474. |
| 800 | 3.22 | 34.32 | 793 | 27.34 | 79.9 | 9.82 | 31.80 | 1476. |
| 1000 | 2.87 | 34.40 | 990 | 27.44 | 70.8 | 11.32 | 45.56 | 1478. |
| 1200 | 2.61 | 34.46 | 1188 | 27.51 | 64.9 | 12.69 | 60.84 | 1480. |
| 1500 | 2.33 | 34.52 | 1484 | 27.58 | 59.0 | 14.54 | 86.22 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-104

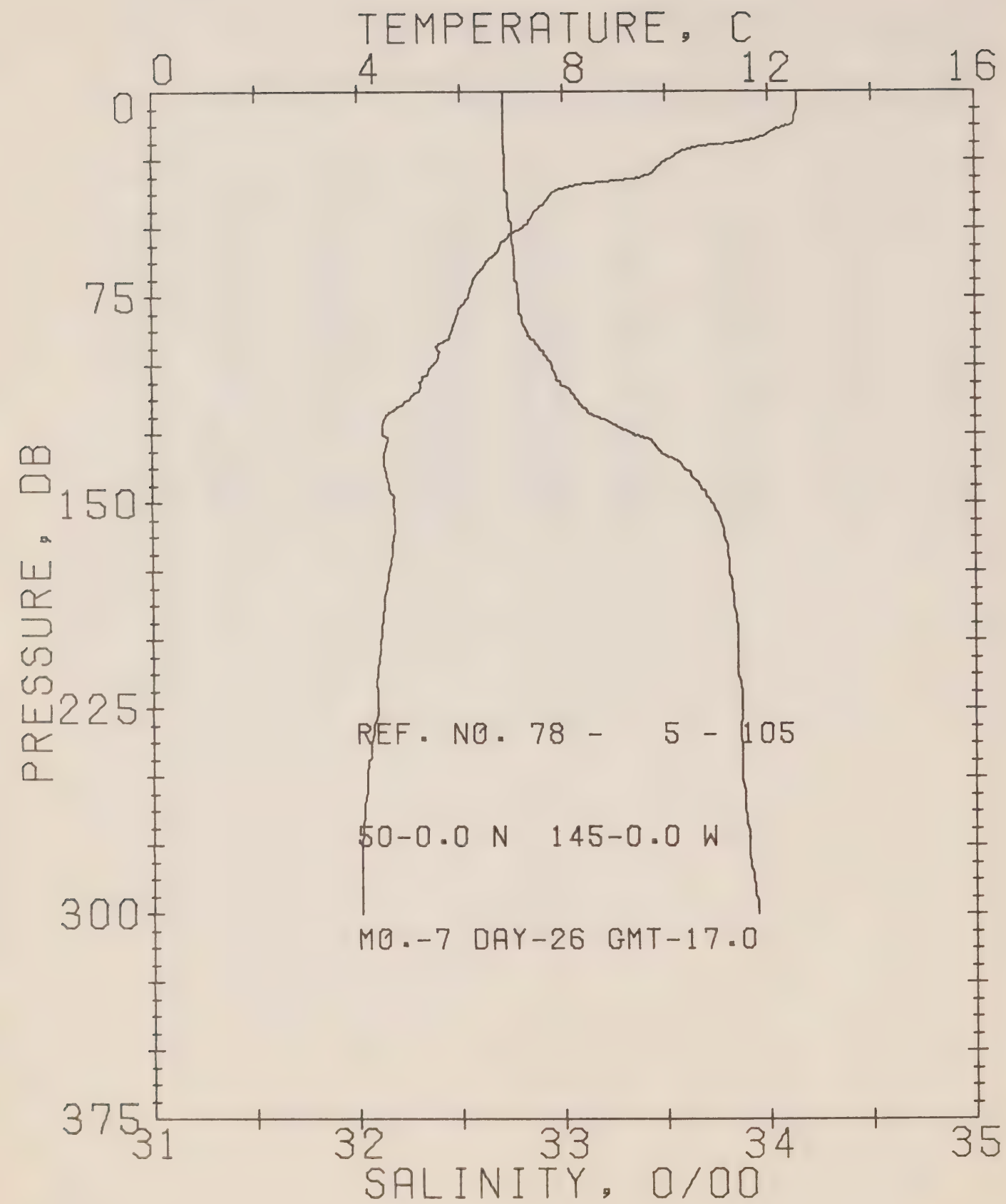
DATE 25/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 193 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 12.50 | 32.71 | 0 | 24.74 | 321.4 | .00 | .00 | 1496. |
| 10 | 12.49 | 32.71 | 10 | 24.74 | 321.3 | .32 | .02 | 1496. |
| 20 | 9.94 | 32.72 | 20 | 25.21 | 277.4 | .63 | .06 | 1488. |
| 30 | 8.60 | 32.73 | 30 | 25.43 | 256.4 | .90 | .13 | 1483. |
| 50 | 6.83 | 32.78 | 50 | 25.72 | 229.0 | 1.38 | .33 | 1476. |
| 75 | 5.96 | 32.81 | 75 | 25.85 | 216.4 | 1.94 | .68 | 1473. |
| 100 | 4.68 | 33.12 | 99 | 26.25 | 179.1 | 2.44 | 1.13 | 1469. |
| 125 | 4.63 | 33.62 | 124 | 26.65 | 141.2 | 2.85 | 1.59 | 1470. |
| 150 | 4.72 | 33.77 | 149 | 26.76 | 131.0 | 3.18 | 2.06 | 1471. |
| 175 | 4.54 | 33.82 | 174 | 26.81 | 126.3 | 3.51 | 2.59 | 1470. |
| 200 | 4.35 | 33.85 | 199 | 26.86 | 121.7 | 3.82 | 3.19 | 1470. |
| 225 | 4.24 | 33.86 | 223 | 26.88 | 120.0 | 4.12 | 3.84 | 1470. |
| 250 | 4.14 | 33.90 | 248 | 26.92 | 116.4 | 4.41 | 4.56 | 1470. |
| 300 | 3.99 | 33.94 | 298 | 26.97 | 112.3 | 4.99 | 6.16 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-105

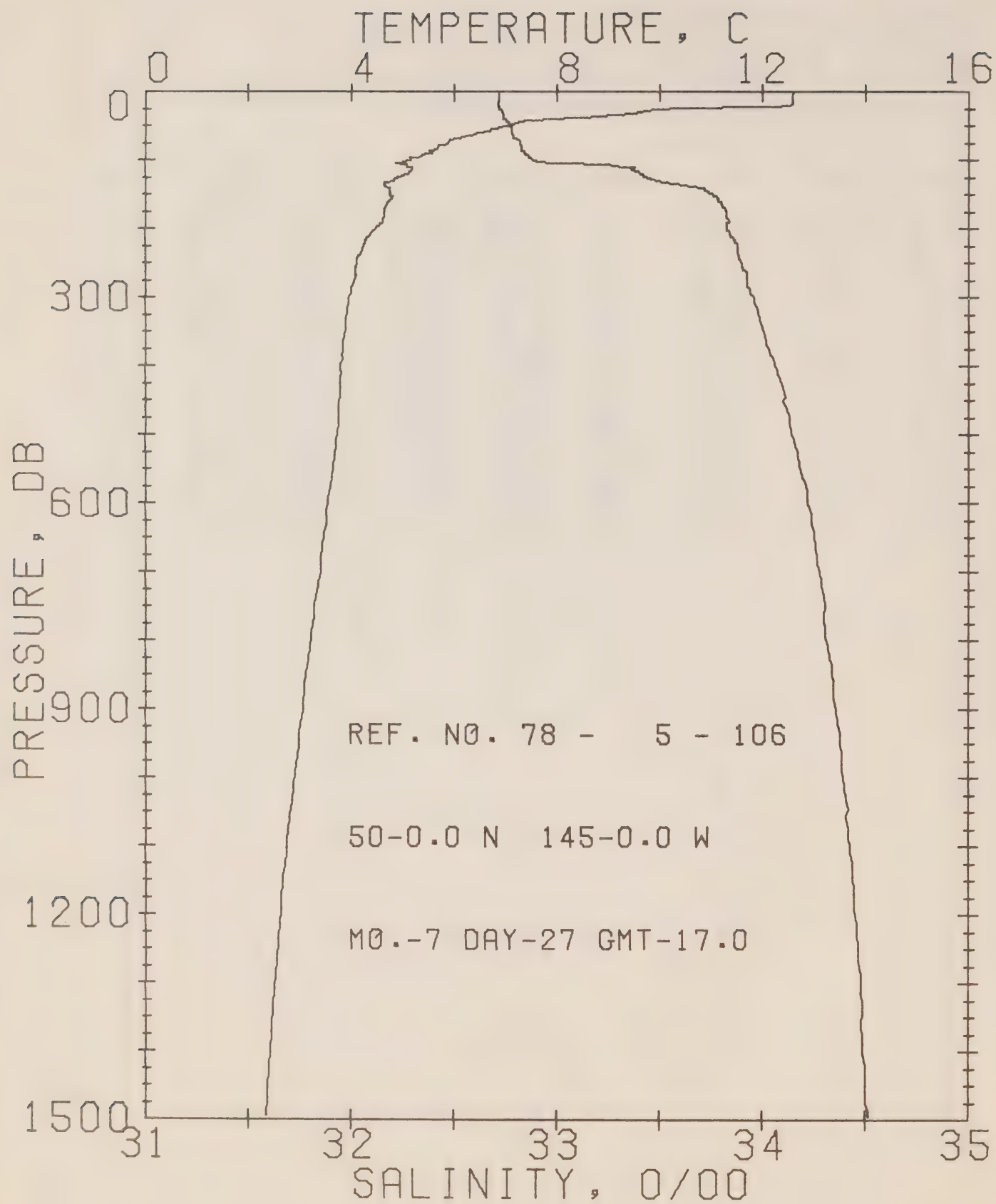
DATE 26/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 201 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 12.57 | 32.71 | 0 | 24.73 | 322.7 | .00 | .00 | 1497. |
| 10 | 12.52 | 32.71 | 10 | 24.74 | 321.9 | .32 | .02 | 1497. |
| 20 | 10.73 | 32.71 | 20 | 25.06 | 290.9 | .64 | .06 | 1490. |
| 30 | 9.75 | 32.72 | 30 | 25.24 | 274.6 | .92 | .14 | 1487. |
| 50 | 7.20 | 32.75 | 50 | 25.64 | 236.1 | 1.41 | .34 | 1478. |
| 75 | 6.17 | 32.79 | 75 | 25.81 | 220.6 | 1.98 | .70 | 1474. |
| 100 | 5.47 | 32.94 | 99 | 26.02 | 201.0 | 2.51 | 1.17 | 1472. |
| 125 | 4.49 | 33.32 | 124 | 26.43 | 162.1 | 2.97 | 1.70 | 1469. |
| 150 | 4.70 | 33.71 | 149 | 26.71 | 135.6 | 3.34 | 2.21 | 1470. |
| 175 | 4.61 | 33.81 | 174 | 26.80 | 127.5 | 3.66 | 2.75 | 1471. |
| 200 | 4.45 | 33.85 | 199 | 26.85 | 122.9 | 3.97 | 3.34 | 1470. |
| 225 | 4.36 | 33.87 | 223 | 26.87 | 120.7 | 4.28 | 4.01 | 1471. |
| 250 | 4.17 | 33.87 | 248 | 26.89 | 119.0 | 4.58 | 4.73 | 1470. |
| 300 | 4.06 | 33.94 | 298 | 26.96 | 113.0 | 5.16 | 6.36 | 1471. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-106

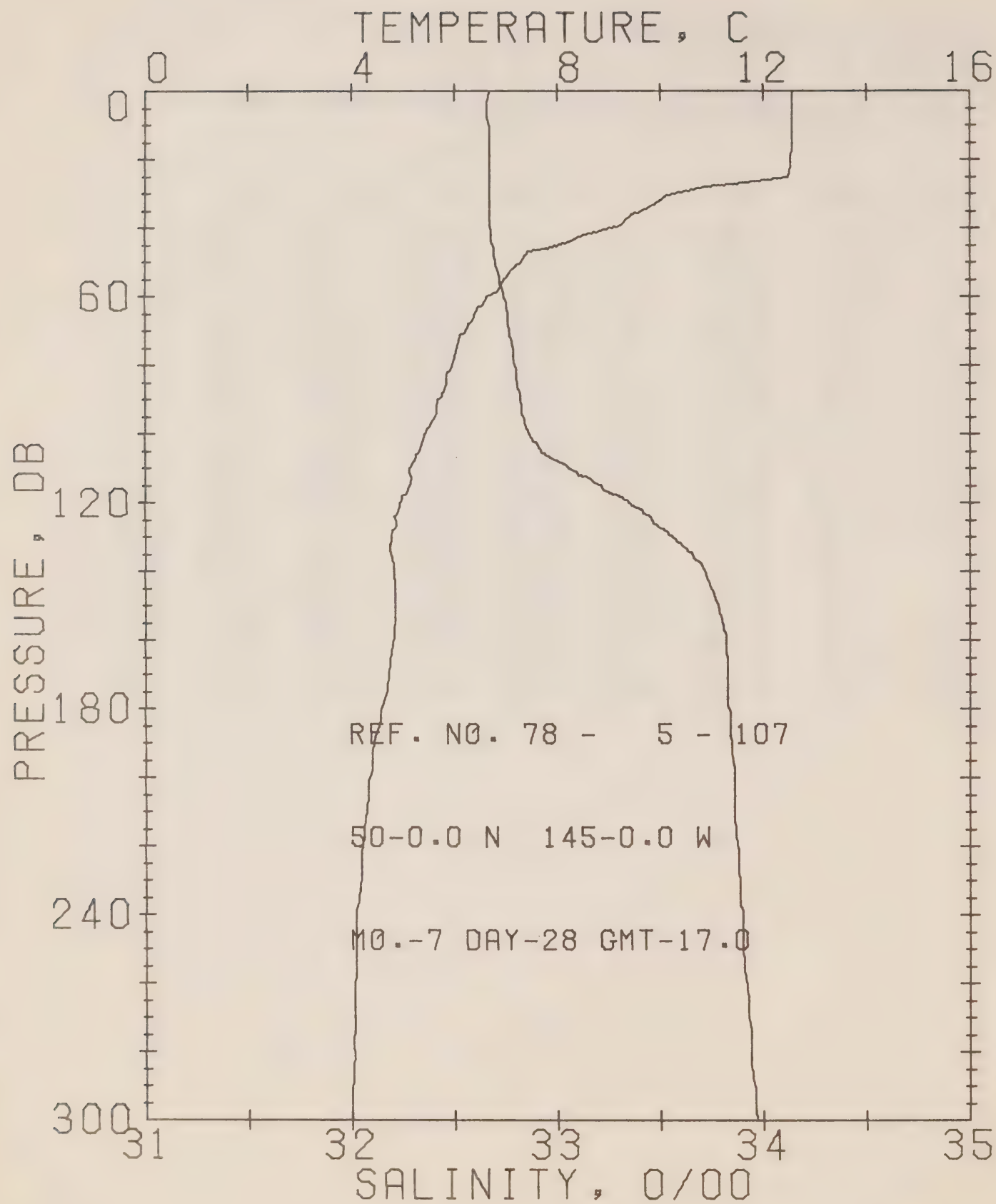
DATE 27/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 312 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 12.61 | 32.72 | 0 | 24.73 | 322.7 | .00 | .00 | 1497. |
| 10 | 12.59 | 32.72 | 10 | 24.73 | 322.5 | .32 | .02 | 1497. |
| 20 | 12.50 | 32.71 | 20 | 24.74 | 321.8 | .65 | .07 | 1497. |
| 30 | 9.64 | 32.73 | 30 | 25.26 | 272.2 | .93 | .14 | 1487. |
| 50 | 7.10 | 32.77 | 50 | 25.67 | 233.2 | 1.43 | .34 | 1477. |
| 75 | 5.87 | 32.82 | 75 | 25.87 | 214.6 | 1.99 | .69 | 1473. |
| 100 | 5.14 | 32.88 | 99 | 26.01 | 201.8 | 2.51 | 1.16 | 1470. |
| 125 | 4.92 | 33.43 | 124 | 26.47 | 158.6 | 2.94 | 1.65 | 1471. |
| 150 | 4.77 | 33.75 | 149 | 26.73 | 133.4 | 3.30 | 2.16 | 1471. |
| 175 | 4.65 | 33.83 | 174 | 26.81 | 126.4 | 3.63 | 2.69 | 1471. |
| 200 | 4.48 | 33.83 | 199 | 26.83 | 124.8 | 3.94 | 3.29 | 1471. |
| 225 | 4.24 | 33.88 | 223 | 26.89 | 118.7 | 4.25 | 3.95 | 1470. |
| 250 | 4.10 | 33.90 | 248 | 26.92 | 116.2 | 4.54 | 4.66 | 1470. |
| 300 | 3.97 | 33.95 | 298 | 26.98 | 111.1 | 5.11 | 6.26 | 1470. |
| 400 | 3.80 | 34.06 | 397 | 27.08 | 102.1 | 6.18 | 10.06 | 1471. |
| 500 | 3.73 | 34.14 | 496 | 27.15 | 96.3 | 7.17 | 14.59 | 1473. |
| 600 | 3.56 | 34.22 | 595 | 27.23 | 89.2 | 8.09 | 19.78 | 1474. |
| 800 | 3.22 | 34.31 | 793 | 27.34 | 80.4 | 9.78 | 31.76 | 1476. |
| 1000 | 2.92 | 34.39 | 990 | 27.43 | 72.4 | 11.29 | 45.65 | 1478. |
| 1200 | 2.63 | 34.45 | 1188 | 27.50 | 66.0 | 12.67 | 61.05 | 1480. |
| 1500 | 2.35 | 34.51 | 1484 | 27.57 | 60.3 | 14.55 | 86.96 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-107

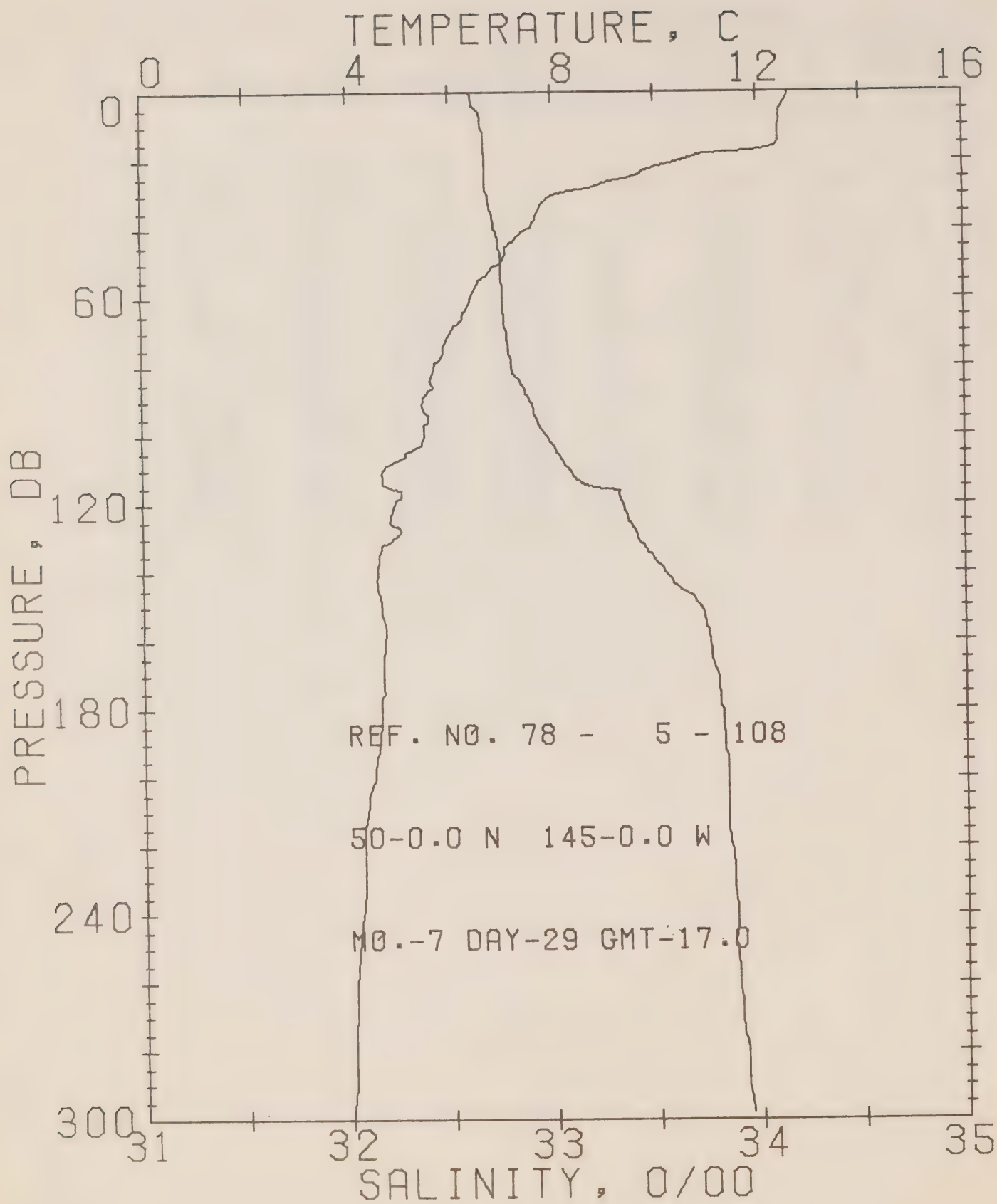
DATE 28/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 174 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 12.56 | 32.67 | 0 | 24.70 | 325.4 | .00 | .00 | 1496. |
| 10 | 12.55 | 32.67 | 10 | 24.70 | 325.7 | .33 | .02 | 1497. |
| 20 | 12.54 | 32.67 | 20 | 24.70 | 325.4 | .65 | .07 | 1497. |
| 30 | 10.29 | 32.67 | 30 | 25.11 | 286.9 | .97 | .15 | 1489. |
| 50 | 7.30 | 32.70 | 50 | 25.59 | 241.1 | 1.50 | .36 | 1478. |
| 75 | 6.06 | 32.79 | 75 | 25.82 | 219.4 | 2.07 | .72 | 1474. |
| 100 | 5.44 | 32.86 | 99 | 25.95 | 207.3 | 2.60 | 1.20 | 1472. |
| 125 | 4.85 | 33.45 | 124 | 26.49 | 156.3 | 3.06 | 1.73 | 1470. |
| 150 | 4.85 | 33.78 | 149 | 26.74 | 132.4 | 3.42 | 2.22 | 1471. |
| 175 | 4.69 | 33.83 | 174 | 26.81 | 126.8 | 3.74 | 2.75 | 1471. |
| 200 | 4.38 | 33.86 | 199 | 26.86 | 121.5 | 4.05 | 3.35 | 1470. |
| 225 | 4.19 | 33.88 | 223 | 26.90 | 118.2 | 4.35 | 4.00 | 1470. |
| 250 | 4.08 | 33.90 | 248 | 26.93 | 115.8 | 4.64 | 4.70 | 1470. |
| 300 | 4.01 | 33.96 | 298 | 26.98 | 111.0 | 5.21 | 6.29 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-108

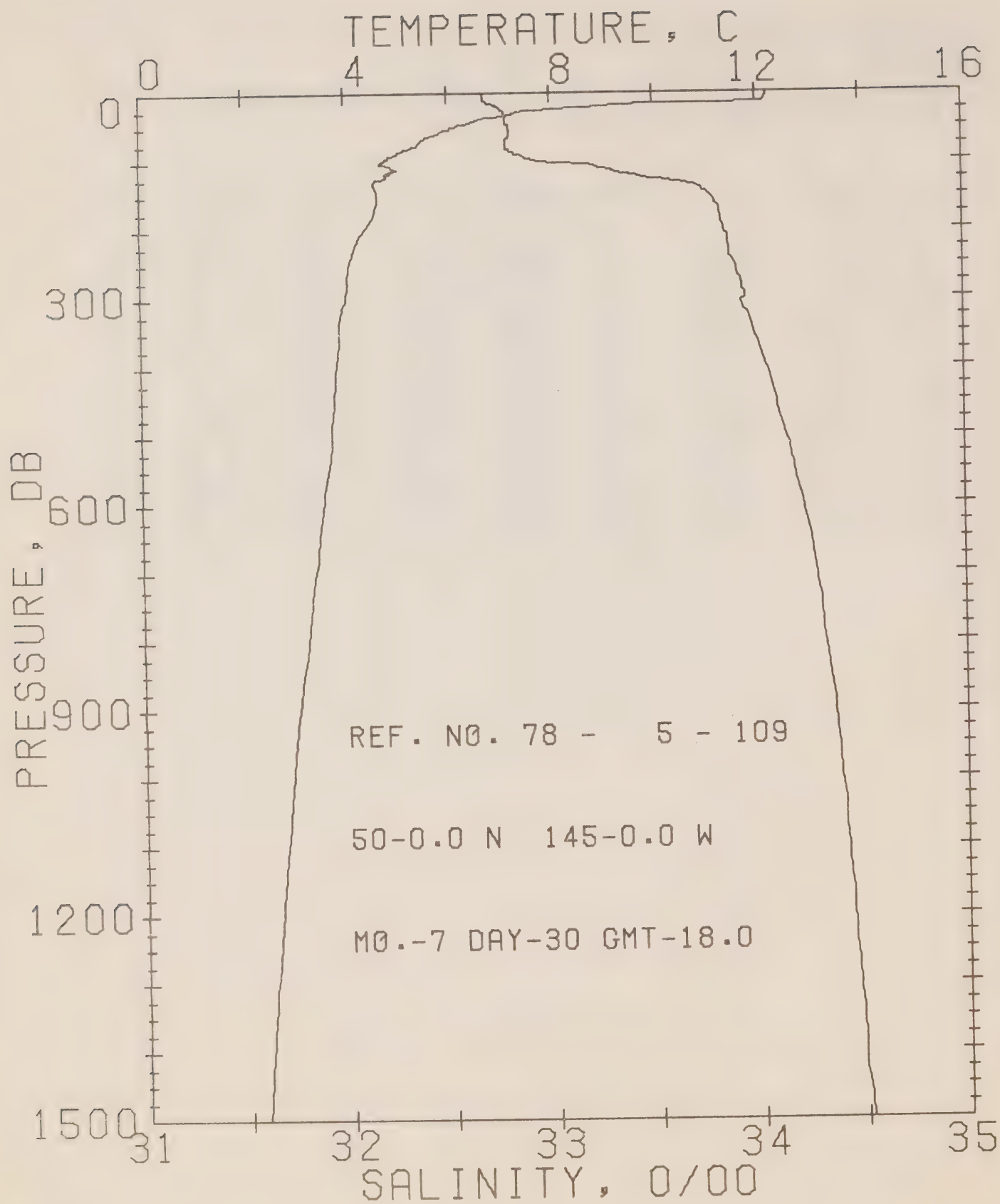
DATE 29/ 7/78

POSITION 50- .0N, 145- .0W GMT 17.0

RESULTS OF STP CAST 189 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 12.62 | 32.60 | 0 | 24.63 | 331.7 | .00 | .00 | 1497. |
| 10 | 12.43 | 32.66 | 10 | 24.72 | 324.0 | .33 | .02 | 1496. |
| 20 | 10.56 | 32.68 | 20 | 25.07 | 290.4 | .64 | .06 | 1490. |
| 30 | 8.05 | 32.69 | 30 | 25.48 | 251.8 | .91 | .13 | 1481. |
| 50 | 6.99 | 32.75 | 50 | 25.67 | 233.3 | 1.40 | .33 | 1477. |
| 75 | 5.87 | 32.79 | 75 | 25.85 | 216.8 | 1.96 | .69 | 1473. |
| 100 | 5.49 | 32.96 | 99 | 26.03 | 200.0 | 2.48 | 1.15 | 1472. |
| 125 | 4.82 | 33.36 | 124 | 26.42 | 162.7 | 2.93 | 1.66 | 1470. |
| 150 | 4.65 | 33.69 | 149 | 26.70 | 136.6 | 3.31 | 2.19 | 1470. |
| 175 | 4.68 | 33.80 | 174 | 26.78 | 128.9 | 3.64 | 2.73 | 1471. |
| 200 | 4.47 | 33.84 | 199 | 26.84 | 123.9 | 3.95 | 3.34 | 1471. |
| 225 | 4.26 | 33.86 | 223 | 26.88 | 120.2 | 4.26 | 4.00 | 1470. |
| 250 | 4.15 | 33.87 | 248 | 26.90 | 118.7 | 4.55 | 4.72 | 1470. |
| 300 | 4.01 | 33.95 | 298 | 26.97 | 111.7 | 5.13 | 6.33 | 1470. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-109

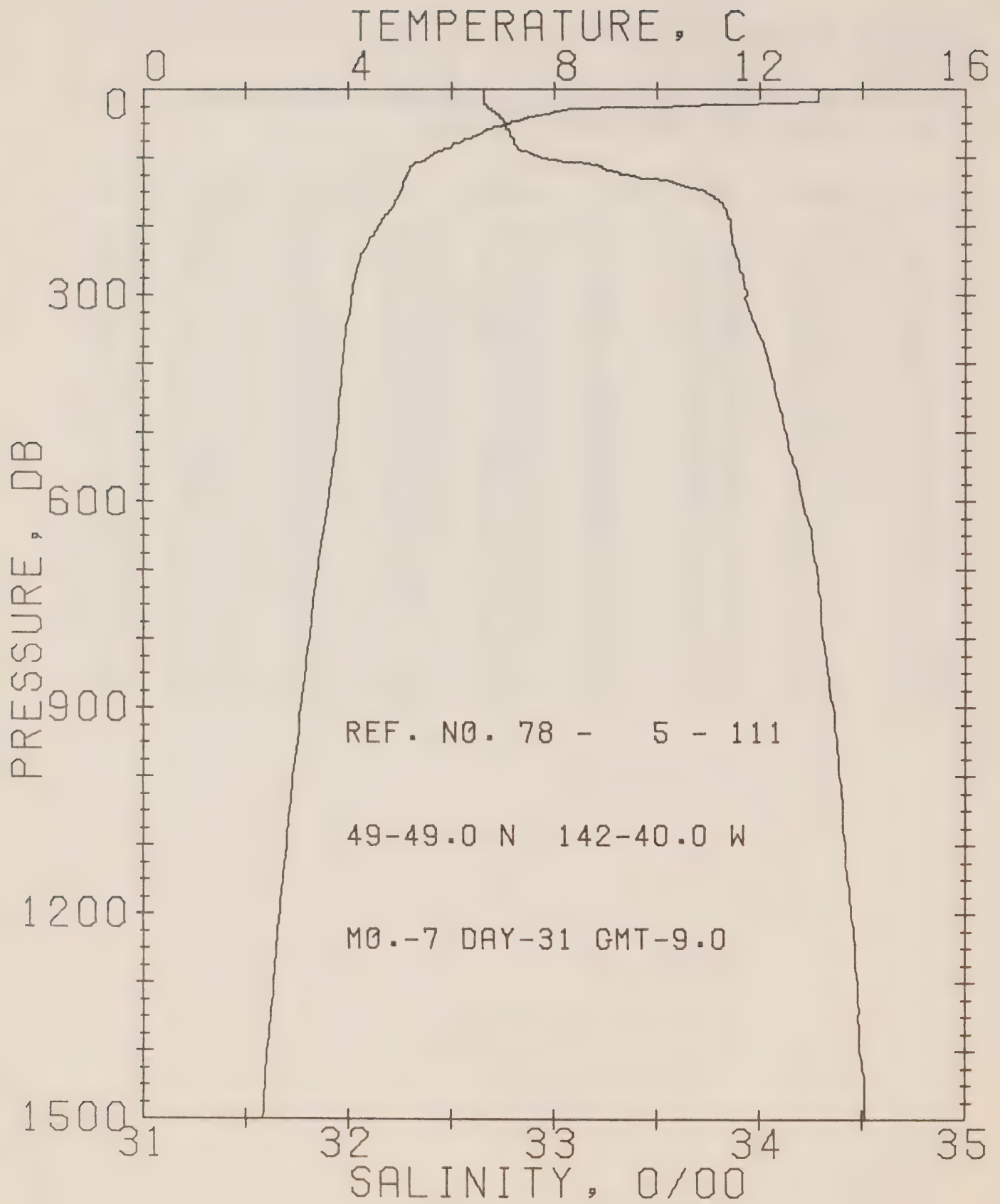
DATE 30/ 7/78

POSITION 50- .0N, 145- .0W GMT 18.0

RESULTS OF STP CAST 223 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 12.22 | 32.68 | 0 | 24.77 | 318.5 | .00 | .00 | 1495. |
| 10 | 12.18 | 32.68 | 10 | 24.78 | 318.0 | .32 | .02 | 1495. |
| 20 | 9.10 | 32.74 | 20 | 25.36 | 262.9 | .61 | .06 | 1484. |
| 30 | 7.34 | 32.78 | 30 | 25.65 | 235.3 | .86 | .12 | 1478. |
| 50 | 6.15 | 32.80 | 50 | 25.82 | 219.2 | 1.31 | .31 | 1474. |
| 75 | 5.43 | 32.79 | 75 | 25.90 | 211.8 | 1.85 | .65 | 1471. |
| 100 | 4.74 | 32.94 | 99 | 26.10 | 193.0 | 2.36 | 1.10 | 1469. |
| 125 | 4.74 | 33.47 | 124 | 26.51 | 154.1 | 2.78 | 1.59 | 1470. |
| 150 | 4.64 | 33.77 | 149 | 26.76 | 130.5 | 3.13 | 2.07 | 1470. |
| 175 | 4.57 | 33.82 | 174 | 26.81 | 126.3 | 3.45 | 2.60 | 1471. |
| 200 | 4.36 | 33.84 | 199 | 26.85 | 122.8 | 3.76 | 3.20 | 1470. |
| 225 | 4.18 | 33.86 | 223 | 26.89 | 119.5 | 4.06 | 3.85 | 1470. |
| 250 | 4.07 | 33.89 | 248 | 26.92 | 116.2 | 4.36 | 4.57 | 1470. |
| 300 | 4.00 | 33.94 | 298 | 26.97 | 112.4 | 4.93 | 6.16 | 1470. |
| 400 | 3.81 | 34.03 | 397 | 27.06 | 104.1 | 6.01 | 10.03 | 1471. |
| 500 | 3.72 | 34.13 | 496 | 27.15 | 96.9 | 7.02 | 14.62 | 1473. |
| 600 | 3.54 | 34.21 | 595 | 27.23 | 89.6 | 7.95 | 19.85 | 1474. |
| 800 | 3.20 | 34.32 | 793 | 27.34 | 79.7 | 9.63 | 31.82 | 1476. |
| 1000 | 2.89 | 34.39 | 990 | 27.43 | 72.3 | 11.14 | 45.65 | 1478. |
| 1200 | 2.64 | 34.44 | 1188 | 27.49 | 66.9 | 12.53 | 61.18 | 1480. |
| 1500 | 2.33 | 34.51 | 1484 | 27.58 | 59.5 | 14.43 | 87.22 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-111

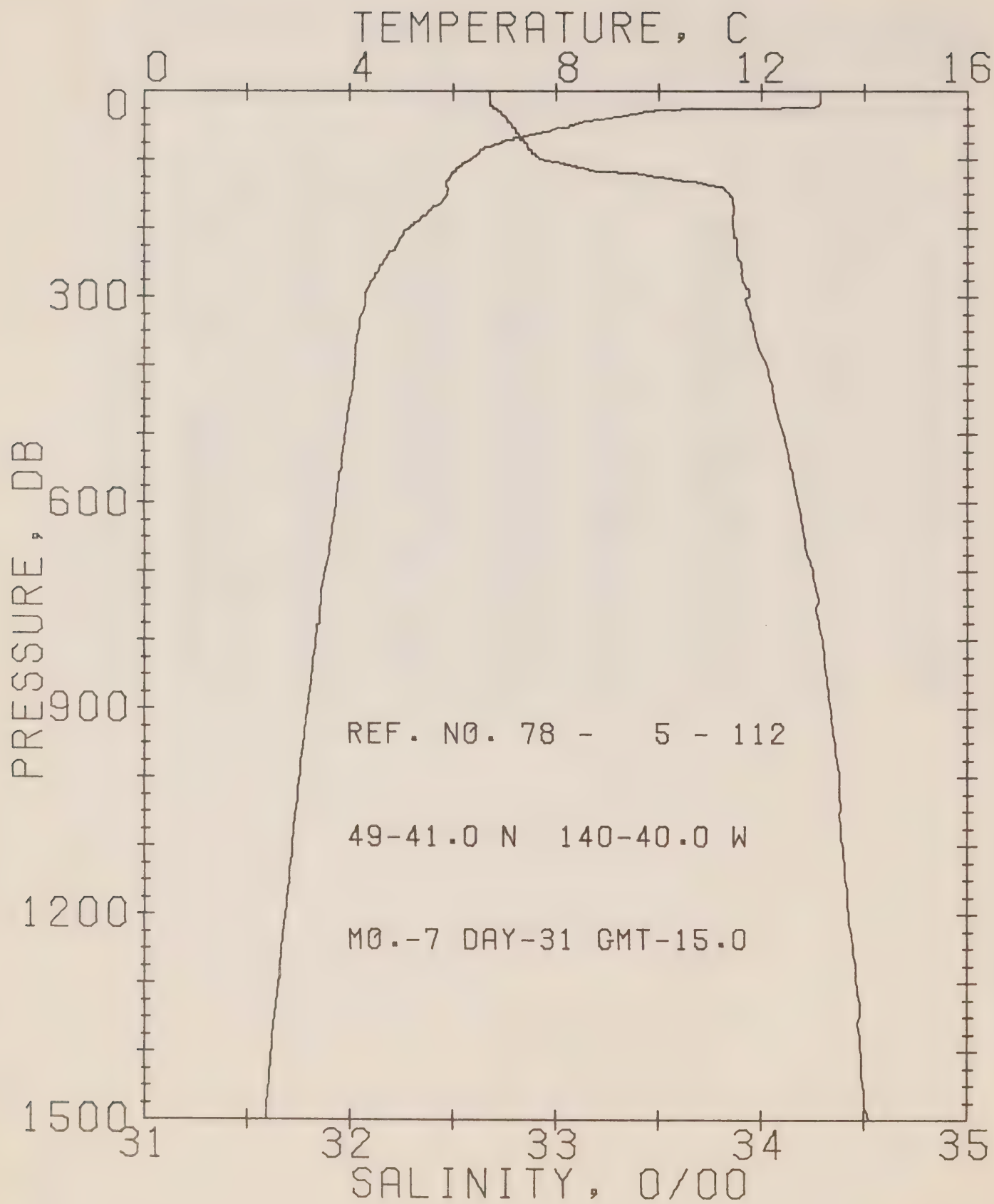
DATE 31/ 7/78

POSITION 49-49.0N, 142-40.0W GMT 9.0

RESULTS OF STP CAST 257 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 13.16 | 32.66 | 0 | 24.57 | 337.3 | .00 | .00 | 1498. |
| 10 | 13.14 | 32.66 | 10 | 24.58 | 337.2 | .34 | .02 | 1499. |
| 20 | 12.39 | 32.66 | 20 | 24.72 | 323.5 | .67 | .07 | 1496. |
| 30 | 8.21 | 32.69 | 30 | 25.45 | 253.9 | .96 | .14 | 1481. |
| 50 | 7.12 | 32.76 | 50 | 25.66 | 234.2 | 1.44 | .34 | 1477. |
| 75 | 6.23 | 32.81 | 75 | 25.82 | 219.6 | 2.01 | .70 | 1474. |
| 100 | 5.53 | 32.95 | 99 | 26.01 | 201.4 | 2.54 | 1.17 | 1472. |
| 125 | 5.14 | 33.35 | 124 | 26.37 | 167.3 | 3.00 | 1.69 | 1471. |
| 150 | 5.01 | 33.74 | 149 | 26.69 | 137.2 | 3.37 | 2.21 | 1472. |
| 175 | 4.84 | 33.84 | 174 | 26.79 | 128.0 | 3.70 | 2.76 | 1472. |
| 200 | 4.59 | 33.86 | 199 | 26.84 | 123.7 | 4.01 | 3.36 | 1471. |
| 225 | 4.38 | 33.87 | 223 | 26.87 | 120.9 | 4.32 | 4.02 | 1471. |
| 250 | 4.22 | 33.90 | 248 | 26.91 | 117.4 | 4.62 | 4.74 | 1470. |
| 300 | 4.07 | 33.94 | 298 | 26.96 | 113.1 | 5.19 | 6.36 | 1471. |
| 400 | 3.88 | 34.04 | 397 | 27.06 | 104.3 | 6.28 | 10.24 | 1472. |
| 500 | 3.80 | 34.12 | 496 | 27.13 | 98.3 | 7.30 | 14.88 | 1473. |
| 600 | 3.62 | 34.20 | 595 | 27.21 | 91.1 | 8.24 | 20.18 | 1474. |
| 800 | 3.25 | 34.31 | 793 | 27.33 | 80.6 | 9.94 | 32.23 | 1476. |
| 1000 | 2.93 | 34.39 | 990 | 27.43 | 72.6 | 11.47 | 46.22 | 1478. |
| 1200 | 2.67 | 34.45 | 1188 | 27.49 | 66.8 | 12.86 | 61.86 | 1480. |
| 1500 | 2.34 | 34.51 | 1484 | 27.57 | 59.9 | 14.75 | 87.76 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-112

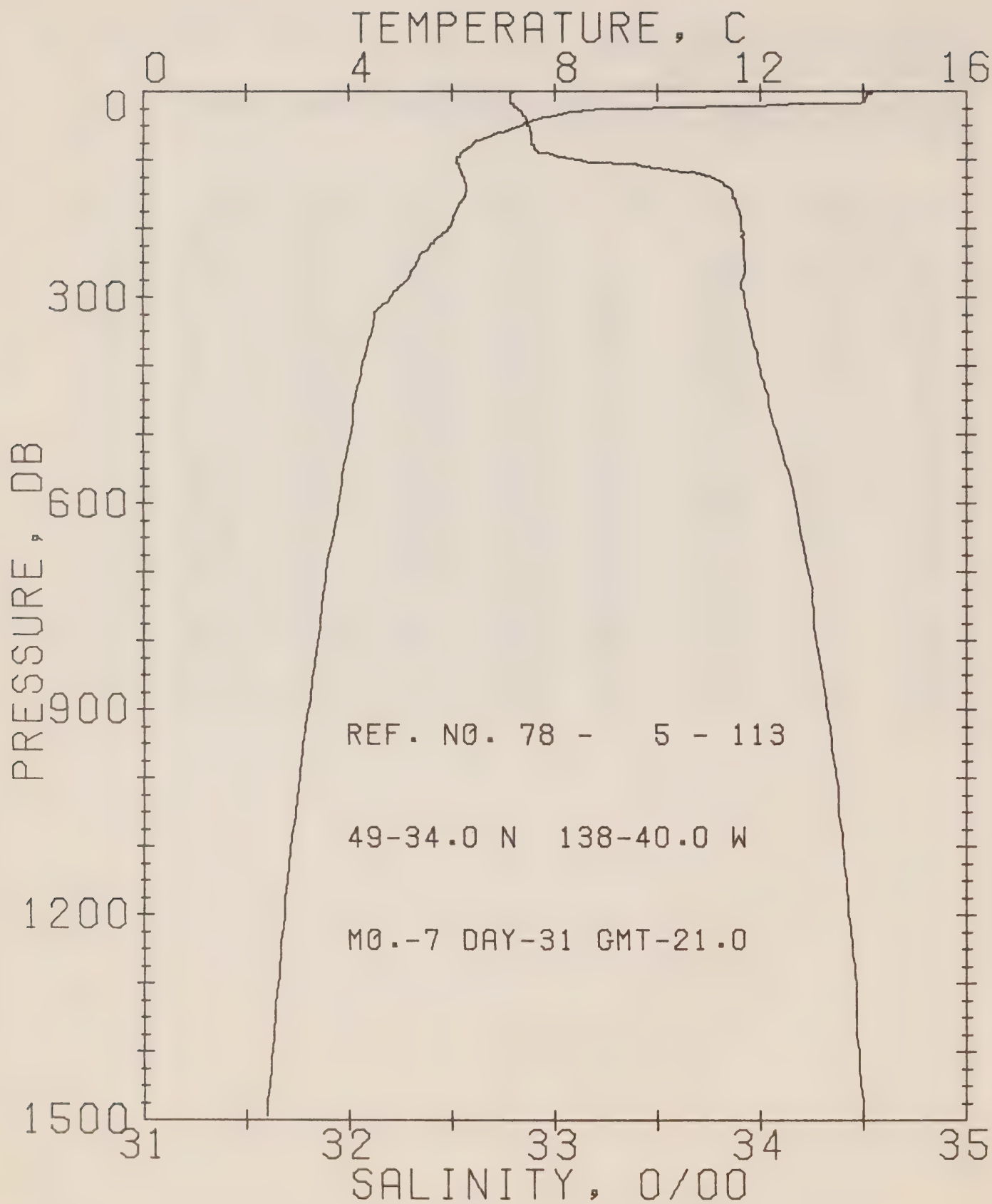
DATE 31/ 7/78

POSITION 49-41.0N, 140-40.0W GMT 15.0

RESULTS OF STP CAST 270 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 13.15 | 32.68 | 0 | 24.59 | 335.6 | .00 | .00 | 1498. |
| 10 | 13.15 | 32.68 | 10 | 24.59 | 335.8 | .34 | .02 | 1499. |
| 20 | 13.13 | 32.68 | 20 | 24.59 | 335.8 | .67 | .07 | 1499. |
| 30 | 9.90 | 32.72 | 30 | 25.21 | 277.1 | .98 | .15 | 1488. |
| 50 | 8.34 | 32.79 | 50 | 25.51 | 248.9 | 1.50 | .36 | 1482. |
| 75 | 6.96 | 32.85 | 75 | 25.76 | 225.8 | 2.10 | .74 | 1477. |
| 100 | 6.35 | 32.92 | 99 | 25.89 | 213.1 | 2.64 | 1.22 | 1475. |
| 125 | 5.96 | 33.47 | 124 | 26.37 | 167.8 | 3.13 | 1.78 | 1475. |
| 150 | 5.89 | 33.84 | 149 | 26.67 | 139.5 | 3.50 | 2.30 | 1476. |
| 175 | 5.55 | 33.87 | 174 | 26.74 | 133.6 | 3.85 | 2.87 | 1475. |
| 200 | 5.16 | 33.86 | 199 | 26.78 | 130.1 | 4.18 | 3.50 | 1473. |
| 225 | 4.93 | 33.88 | 223 | 26.82 | 126.3 | 4.50 | 4.19 | 1473. |
| 250 | 4.65 | 33.90 | 248 | 26.86 | 122.2 | 4.81 | 4.94 | 1472. |
| 300 | 4.29 | 33.94 | 298 | 26.94 | 115.4 | 5.40 | 6.61 | 1472. |
| 400 | 4.10 | 34.02 | 397 | 27.02 | 108.2 | 6.53 | 10.62 | 1472. |
| 500 | 3.92 | 34.10 | 496 | 27.10 | 101.1 | 7.58 | 15.43 | 1473. |
| 600 | 3.74 | 34.17 | 595 | 27.18 | 94.9 | 8.56 | 20.91 | 1474. |
| 800 | 3.35 | 34.29 | 793 | 27.31 | 83.2 | 10.33 | 33.50 | 1476. |
| 1000 | 3.03 | 34.38 | 990 | 27.41 | 74.6 | 11.90 | 47.95 | 1478. |
| 1200 | 2.77 | 34.42 | 1188 | 27.47 | 69.8 | 13.35 | 64.16 | 1481. |
| 1500 | 2.38 | 34.50 | 1484 | 27.56 | 60.9 | 15.29 | 90.75 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-113

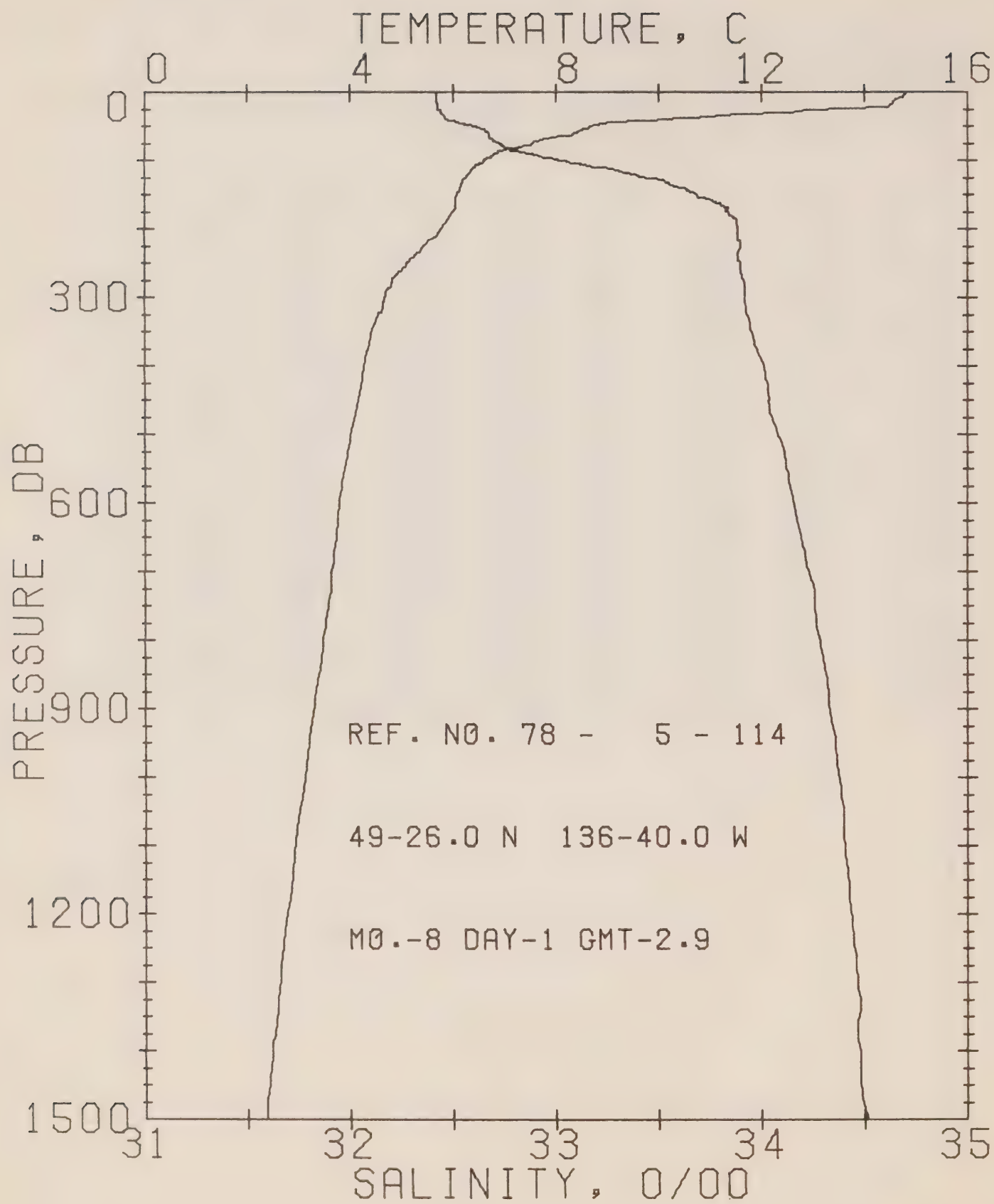
DATE 31/ 7/78

POSITION 49-34.0N, 138-40.0W GMT 21.0

RESULTS OF STP CAST 256 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 14.15 | 32.80 | 0 | 24.48 | 346.2 | .00 | .00 | 1502. |
| 10 | 14.05 | 32.79 | 10 | 24.49 | 345.2 | .35 | .02 | 1502. |
| 20 | 12.38 | 32.80 | 20 | 24.83 | 313.0 | .69 | .07 | 1496. |
| 30 | 8.48 | 32.84 | 30 | 25.53 | 246.7 | .96 | .14 | 1482. |
| 50 | 7.36 | 32.87 | 50 | 25.72 | 229.1 | 1.43 | .33 | 1478. |
| 75 | 6.44 | 32.89 | 75 | 25.86 | 216.2 | 1.98 | .68 | 1475. |
| 100 | 6.10 | 33.11 | 99 | 26.07 | 196.2 | 2.51 | 1.15 | 1475. |
| 125 | 6.25 | 33.74 | 124 | 26.55 | 151.0 | 2.94 | 1.64 | 1476. |
| 150 | 6.28 | 33.87 | 149 | 26.65 | 142.1 | 3.30 | 2.15 | 1477. |
| 175 | 6.10 | 33.90 | 174 | 26.69 | 138.2 | 3.65 | 2.73 | 1477. |
| 200 | 5.96 | 33.91 | 199 | 26.72 | 135.9 | 3.99 | 3.38 | 1477. |
| 225 | 5.59 | 33.92 | 223 | 26.77 | 130.9 | 4.33 | 4.10 | 1476. |
| 250 | 5.33 | 33.93 | 248 | 26.81 | 127.5 | 4.65 | 4.88 | 1475. |
| 300 | 4.82 | 33.92 | 298 | 26.86 | 122.8 | 5.28 | 6.65 | 1474. |
| 400 | 4.27 | 33.99 | 397 | 26.98 | 112.3 | 6.44 | 10.80 | 1473. |
| 500 | 4.06 | 34.08 | 496 | 27.07 | 104.3 | 7.52 | 15.75 | 1474. |
| 600 | 3.81 | 34.17 | 595 | 27.16 | 96.0 | 8.52 | 21.34 | 1475. |
| 800 | 3.42 | 34.27 | 793 | 27.28 | 85.6 | 10.32 | 34.14 | 1476. |
| 1000 | 3.05 | 34.37 | 990 | 27.40 | 75.4 | 11.93 | 48.84 | 1476. |
| 1200 | 2.74 | 34.43 | 1188 | 27.48 | 68.8 | 13.37 | 64.98 | 1480. |
| 1500 | 2.40 | 34.50 | 1484 | 27.56 | 61.3 | 15.32 | 91.71 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-114

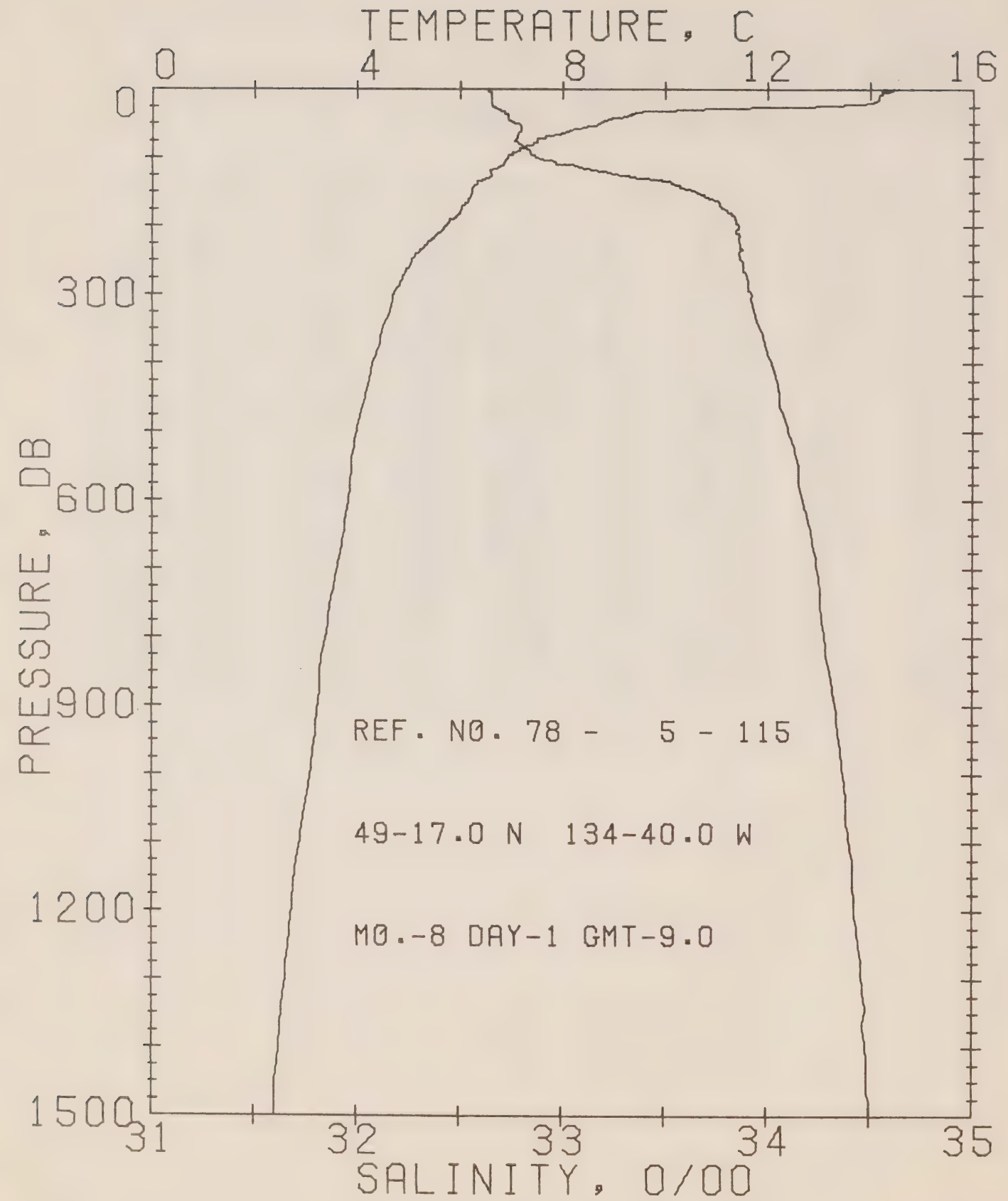
DATE 1/ 8/78

POSITION 49-26.0N, 136-40.0W GMT 2.9

RESULTS OF STP CAST 283 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 14.79 | 32.42 | 0 | 24.05 | 386.8 | .00 | .00 | 1504. |
| 10 | 14.60 | 32.42 | 10 | 24.09 | 383.3 | .39 | .02 | 1503. |
| 20 | 14.48 | 32.43 | 20 | 24.13 | 380.4 | .77 | .08 | 1503. |
| 30 | 12.59 | 32.44 | 30 | 24.51 | 343.6 | 1.13 | .17 | 1497. |
| 50 | 8.70 | 32.59 | 50 | 25.31 | 268.3 | 1.73 | .41 | 1483. |
| 75 | 7.54 | 32.72 | 75 | 25.58 | 242.8 | 2.37 | .82 | 1479. |
| 100 | 6.60 | 33.02 | 99 | 25.94 | 208.7 | 2.94 | 1.32 | 1477. |
| 125 | 6.27 | 33.42 | 124 | 26.30 | 175.0 | 3.41 | 1.87 | 1476. |
| 150 | 6.08 | 33.68 | 149 | 26.52 | 153.8 | 3.82 | 2.44 | 1470. |
| 175 | 6.00 | 33.83 | 174 | 26.65 | 141.8 | 4.19 | 3.04 | 1476. |
| 200 | 5.79 | 33.89 | 199 | 26.72 | 135.3 | 4.53 | 3.70 | 1476. |
| 225 | 5.44 | 33.90 | 223 | 26.78 | 130.6 | 4.86 | 4.42 | 1475. |
| 250 | 5.12 | 33.90 | 248 | 26.81 | 127.2 | 5.19 | 5.21 | 1474. |
| 300 | 4.69 | 33.92 | 298 | 26.88 | 121.3 | 5.81 | 6.94 | 1473. |
| 400 | 4.27 | 34.01 | 397 | 26.99 | 111.1 | 6.97 | 11.09 | 1473. |
| 500 | 4.02 | 34.07 | 496 | 27.07 | 104.2 | 8.05 | 16.05 | 1474. |
| 600 | 3.80 | 34.15 | 595 | 27.15 | 97.0 | 9.05 | 21.65 | 1475. |
| 800 | 3.49 | 34.28 | 793 | 27.29 | 85.6 | 10.87 | 34.58 | 1477. |
| 1000 | 3.13 | 34.37 | 990 | 27.40 | 75.9 | 12.48 | 49.30 | 1479. |
| 1200 | 2.80 | 34.43 | 1188 | 27.47 | 69.1 | 13.92 | 65.48 | 1481. |
| 1500 | 2.37 | 34.50 | 1484 | 27.56 | 61.0 | 15.87 | 92.19 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-115

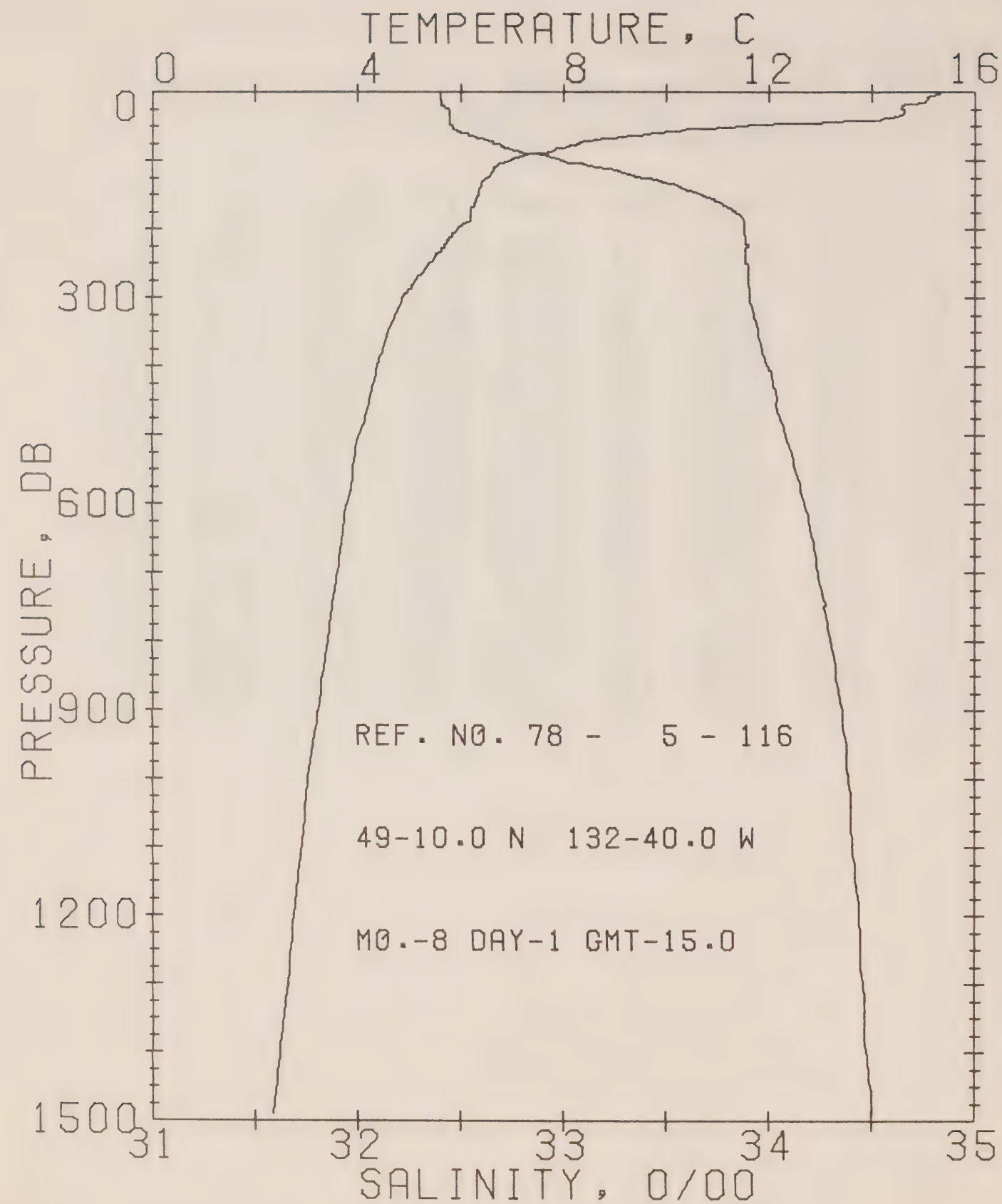
DATE 1/ 8/78

POSITION 49-17.0N, 134-40.0W GMT 9.0

RESULTS OF STP CAST 304 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 14.46 | 32.64 | 0 | 24.29 | 364.1 | .00 | .00 | 1503. |
| 10 | 14.18 | 32.65 | 10 | 24.36 | 358.0 | .36 | .02 | 1502. |
| 20 | 14.03 | 32.65 | 20 | 24.39 | 355.4 | .72 | .07 | 1502. |
| 30 | 10.51 | 32.69 | 30 | 25.08 | 289.3 | 1.05 | .16 | 1490. |
| 50 | 8.73 | 32.77 | 50 | 25.44 | 255.9 | 1.58 | .37 | 1484. |
| 75 | 7.52 | 32.77 | 75 | 25.62 | 239.0 | 2.19 | .76 | 1479. |
| 100 | 6.94 | 32.87 | 99 | 25.77 | 224.4 | 2.77 | 1.28 | 1478. |
| 125 | 6.62 | 33.27 | 124 | 26.13 | 190.5 | 3.29 | 1.88 | 1477. |
| 150 | 6.23 | 33.64 | 149 | 26.47 | 158.6 | 3.72 | 2.47 | 1477. |
| 175 | 6.03 | 33.78 | 174 | 26.61 | 146.1 | 4.10 | 3.10 | 1476. |
| 200 | 5.72 | 33.86 | 199 | 26.71 | 136.6 | 4.45 | 3.77 | 1476. |
| 225 | 5.39 | 33.86 | 223 | 26.75 | 132.8 | 4.79 | 4.50 | 1475. |
| 250 | 5.08 | 33.87 | 248 | 26.79 | 128.9 | 5.12 | 5.29 | 1474. |
| 300 | 4.72 | 33.92 | 298 | 26.87 | 121.6 | 5.74 | 7.05 | 1473. |
| 400 | 4.31 | 34.02 | 397 | 27.00 | 110.8 | 6.91 | 11.20 | 1473. |
| 500 | 4.00 | 34.10 | 496 | 27.09 | 102.1 | 7.97 | 16.08 | 1474. |
| 600 | 3.84 | 34.17 | 595 | 27.16 | 96.3 | 8.96 | 21.61 | 1475. |
| 800 | 3.41 | 34.28 | 793 | 27.29 | 84.7 | 10.75 | 34.36 | 1476. |
| 1000 | 3.11 | 34.37 | 990 | 27.39 | 76.0 | 12.36 | 49.02 | 1479. |
| 1200 | 2.75 | 34.43 | 1188 | 27.48 | 68.8 | 13.80 | 65.17 | 1480. |
| 1500 | 2.39 | 34.50 | 1484 | 27.56 | 61.2 | 15.74 | 91.80 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-116

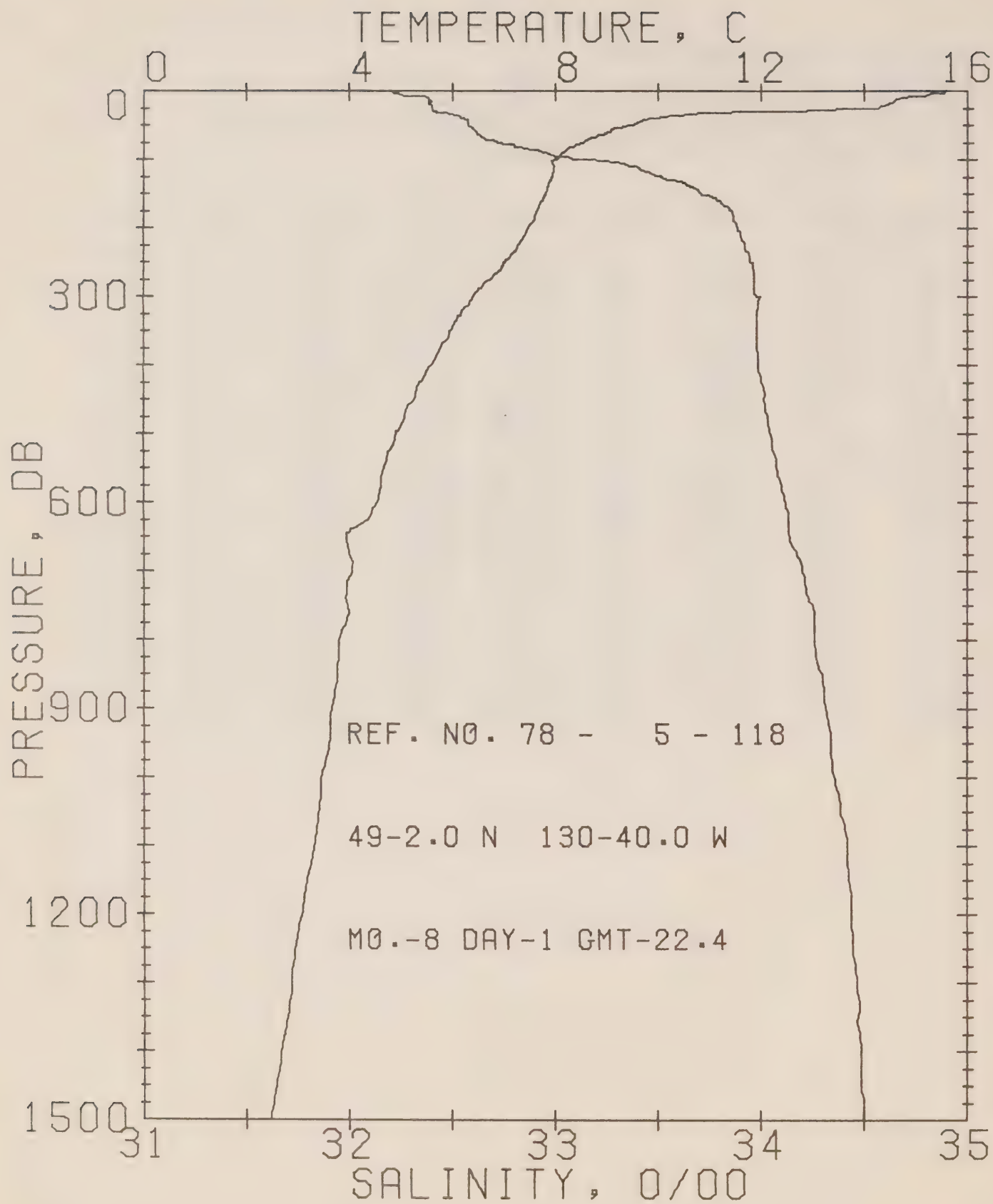
DATE 1/ 8/78

POSITION 49-10.0N, 132-40.0W GMT 15.0

RESULTS OF STP CAST 285 POINTS TAKEN FROM ANALOG TRACE

BISETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 15.34 | 32.40 | 0 | 23.92 | 399.6 | .00 | .00 | 1505. |
| 10 | 15.08 | 32.40 | 10 | 23.98 | 394.5 | .40 | .02 | 1505. |
| 20 | 14.59 | 32.41 | 20 | 24.09 | 384.1 | .79 | .08 | 1503. |
| 30 | 14.64 | 32.45 | 30 | 24.11 | 382.4 | 1.17 | .18 | 1504. |
| 50 | 11.63 | 32.45 | 50 | 24.71 | 325.8 | 1.90 | .47 | 1494. |
| 75 | 8.30 | 32.66 | 75 | 25.42 | 258.1 | 2.62 | .93 | 1482. |
| 100 | 6.96 | 32.98 | 99 | 25.86 | 216.1 | 3.22 | 1.46 | 1478. |
| 125 | 6.53 | 33.37 | 124 | 26.22 | 182.6 | 3.71 | 2.02 | 1477. |
| 150 | 6.34 | 33.66 | 149 | 26.47 | 158.5 | 4.13 | 2.61 | 1477. |
| 175 | 6.19 | 33.83 | 174 | 26.63 | 144.4 | 4.51 | 3.23 | 1477. |
| 200 | 5.95 | 33.88 | 199 | 26.70 | 138.0 | 4.86 | 3.91 | 1477. |
| 225 | 5.69 | 33.90 | 224 | 26.75 | 133.6 | 5.20 | 4.64 | 1476. |
| 250 | 5.40 | 33.89 | 248 | 26.77 | 131.2 | 5.53 | 5.45 | 1475. |
| 300 | 4.87 | 33.91 | 298 | 26.85 | 124.1 | 6.17 | 7.23 | 1474. |
| 400 | 4.37 | 33.99 | 397 | 26.97 | 113.5 | 7.36 | 11.47 | 1474. |
| 500 | 4.04 | 34.07 | 496 | 27.07 | 104.5 | 8.45 | 16.47 | 1474. |
| 600 | 3.79 | 34.17 | 595 | 27.17 | 95.9 | 9.45 | 22.06 | 1475. |
| 800 | 3.42 | 34.30 | 793 | 27.31 | 83.4 | 11.23 | 34.76 | 1477. |
| 1000 | 3.04 | 34.38 | 991 | 27.41 | 74.2 | 12.80 | 49.08 | 1478. |
| 1200 | 2.76 | 34.44 | 1188 | 27.48 | 68.2 | 14.23 | 65.08 | 1481. |
| 1500 | 2.36 | 34.50 | 1484 | 27.56 | 60.8 | 16.17 | 91.77 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-118

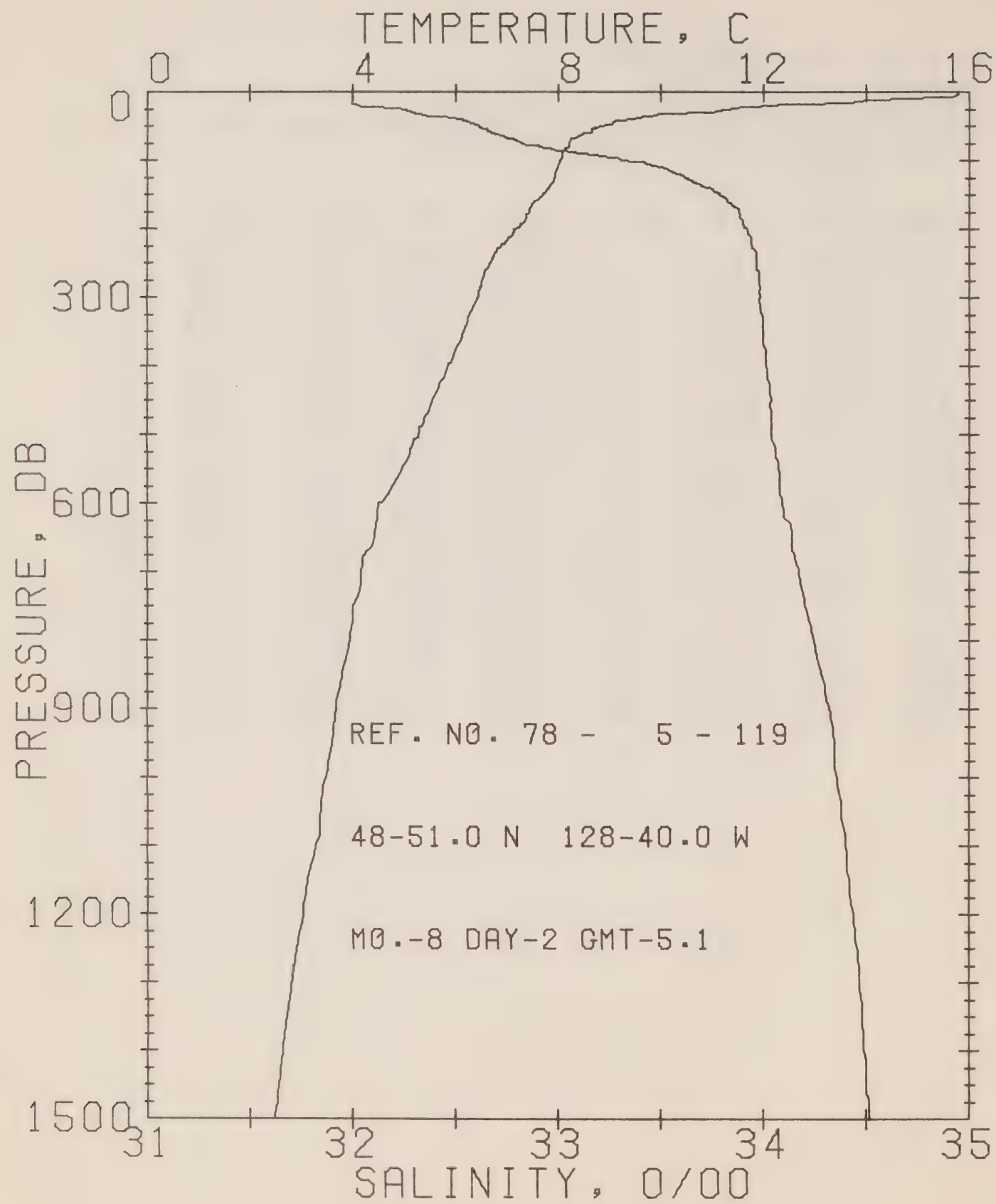
DATE 1/ 8/78

POSITION 49- 2.0N, 130-40.0W GMT 22.4

RESULTS OF STP CAST 337 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 15.58 | 32.20 | 0 | 23.71 | 419.2 | .00 | .00 | 1506. |
| 10 | 14.78 | 32.38 | 10 | 24.02 | 390.0 | .41 | .02 | 1504. |
| 20 | 14.45 | 32.39 | 20 | 24.10 | 382.8 | .79 | .08 | 1503. |
| 30 | 12.68 | 32.41 | 30 | 24.47 | 347.5 | 1.17 | .17 | 1497. |
| 50 | 9.49 | 32.57 | 50 | 25.16 | 282.0 | 1.76 | .41 | 1486. |
| 75 | 8.54 | 32.72 | 75 | 25.43 | 257.4 | 2.43 | .84 | 1483. |
| 100 | 7.99 | 33.12 | 99 | 25.82 | 219.9 | 3.03 | 1.38 | 1482. |
| 125 | 7.94 | 33.51 | 124 | 26.14 | 190.7 | 3.53 | 1.95 | 1483. |
| 150 | 7.81 | 33.70 | 149 | 26.30 | 175.1 | 3.99 | 2.59 | 1483. |
| 175 | 7.65 | 33.85 | 174 | 26.44 | 162.2 | 4.41 | 3.28 | 1483. |
| 200 | 7.48 | 33.89 | 199 | 26.50 | 157.6 | 4.81 | 4.04 | 1483. |
| 225 | 7.29 | 33.92 | 224 | 26.55 | 152.9 | 5.20 | 4.88 | 1482. |
| 250 | 7.03 | 33.95 | 248 | 26.61 | 147.4 | 5.57 | 5.79 | 1482. |
| 300 | 6.41 | 33.98 | 298 | 26.71 | 137.9 | 6.28 | 7.79 | 1480. |
| 400 | 5.63 | 33.99 | 397 | 26.82 | 128.3 | 7.61 | 12.51 | 1479. |
| 500 | 4.92 | 34.04 | 496 | 26.95 | 117.0 | 8.83 | 18.12 | 1478. |
| 600 | 4.55 | 34.11 | 595 | 27.04 | 108.4 | 9.96 | 24.42 | 1478. |
| 800 | 3.82 | 34.26 | 793 | 27.24 | 90.7 | 11.92 | 38.32 | 1478. |
| 1000 | 3.49 | 34.35 | 991 | 27.34 | 81.8 | 13.64 | 54.09 | 1480. |
| 1200 | 3.10 | 34.44 | 1188 | 27.45 | 72.1 | 15.16 | 71.15 | 1482. |
| 1500 | 2.50 | 34.50 | 1484 | 27.55 | 62.4 | 17.18 | 98.81 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-119

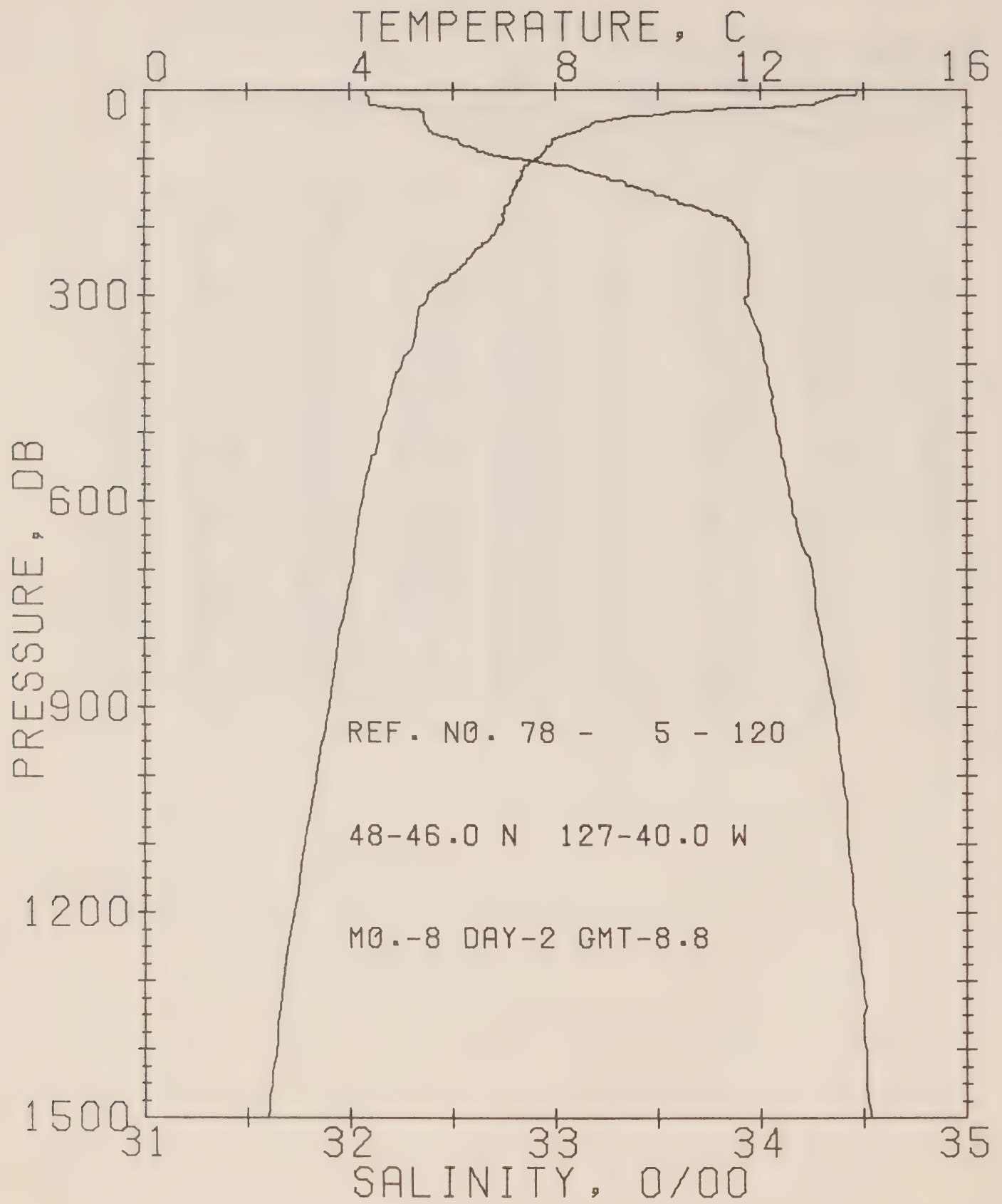
DATE 2/ 8/78

POSITION 48-51.0N, 128-40.0W GMT 5.1

RESULTS OF STP CAST 304 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 15.80 | 32.00 | 0 | 23.51 | 438.5 | .00 | .00 | 1506. |
| 10 | 14.78 | 32.00 | 10 | 23.73 | 417.6 | .44 | .02 | 1503. |
| 20 | 12.14 | 32.03 | 20 | 24.28 | 365.4 | .83 | .08 | 1495. |
| 30 | 11.00 | 32.29 | 30 | 24.69 | 326.7 | 1.17 | .17 | 1491. |
| 50 | 8.85 | 32.61 | 50 | 25.29 | 269.6 | 1.75 | .40 | 1484. |
| 75 | 8.22 | 32.82 | 75 | 25.56 | 244.8 | 2.39 | .81 | 1482. |
| 100 | 8.05 | 33.32 | 99 | 25.97 | 206.1 | 2.96 | 1.31 | 1483. |
| 125 | 7.94 | 33.61 | 124 | 26.22 | 182.9 | 3.44 | 1.86 | 1483. |
| 150 | 7.71 | 33.79 | 149 | 26.39 | 167.1 | 3.87 | 2.48 | 1483. |
| 175 | 7.44 | 33.88 | 174 | 26.50 | 157.1 | 4.28 | 3.14 | 1482. |
| 200 | 7.20 | 33.91 | 199 | 26.56 | 151.8 | 4.66 | 3.88 | 1482. |
| 225 | 6.90 | 33.94 | 223 | 26.62 | 145.9 | 5.04 | 4.69 | 1481. |
| 250 | 6.69 | 33.97 | 248 | 26.67 | 141.4 | 5.39 | 5.55 | 1481. |
| 300 | 6.45 | 33.99 | 298 | 26.72 | 137.4 | 6.09 | 7.50 | 1480. |
| 400 | 5.87 | 34.01 | 397 | 26.81 | 129.8 | 7.43 | 12.27 | 1480. |
| 500 | 5.29 | 34.04 | 496 | 26.90 | 121.5 | 8.68 | 18.00 | 1479. |
| 600 | 4.58 | 34.09 | 595 | 27.02 | 110.3 | 9.84 | 24.50 | 1478. |
| 800 | 3.94 | 34.24 | 793 | 27.21 | 93.5 | 11.87 | 38.95 | 1479. |
| 1000 | 3.50 | 34.35 | 991 | 27.34 | 81.7 | 13.60 | 54.80 | 1480. |
| 1200 | 3.04 | 34.43 | 1188 | 27.45 | 71.9 | 15.14 | 71.97 | 1482. |
| 1500 | 2.51 | 34.51 | 1484 | 27.56 | 61.8 | 17.13 | 99.28 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-120

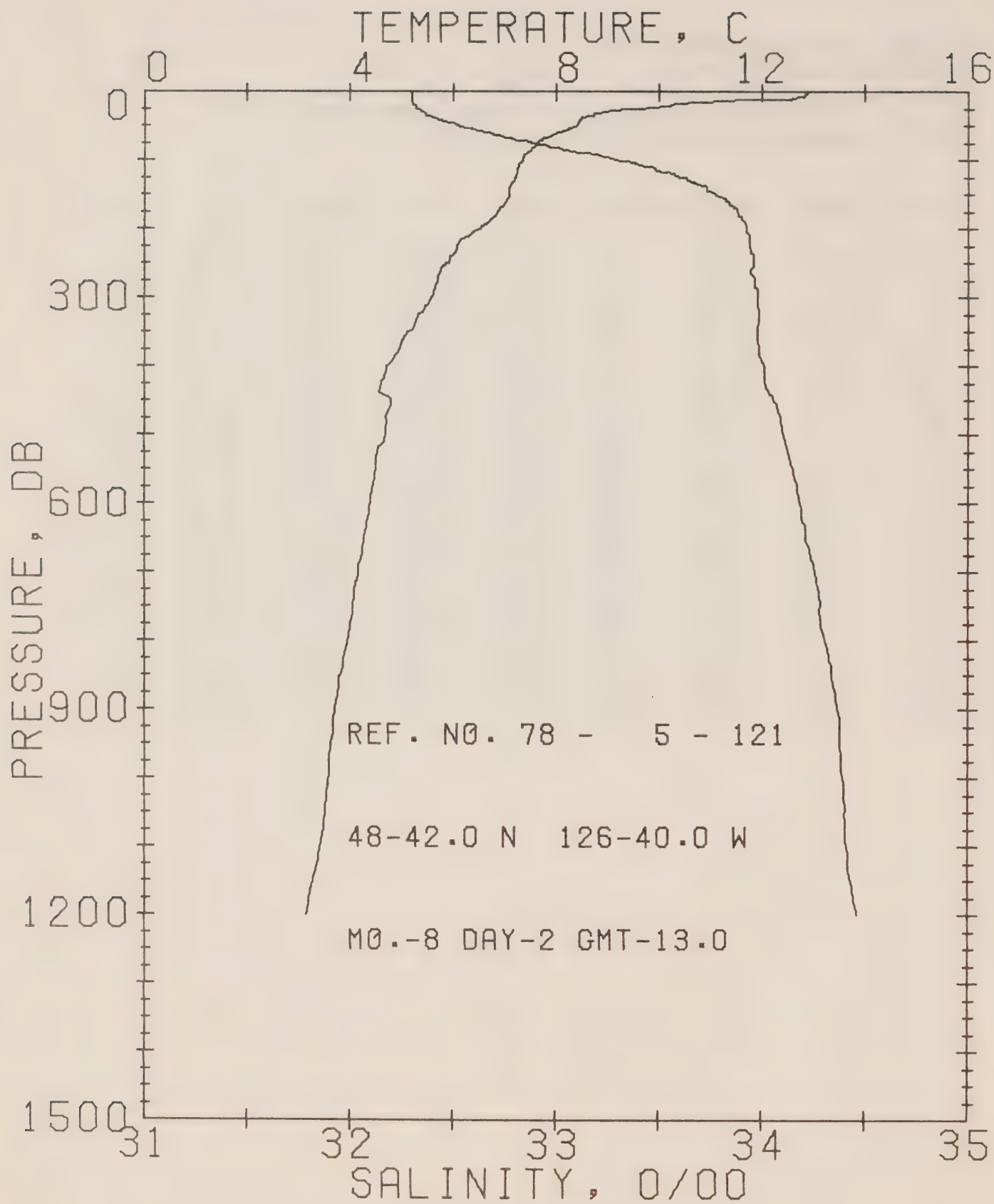
DATE 2/ 8/78

POSITION 48-46.0N, 127-40.0W GMT 8.8

RESULTS OF STP CAST 305 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 13.88 | 32.08 | 0 | 23.98 | 393.7 | .00 | .00 | 1500. |
| 10 | 13.50 | 32.09 | 10 | 24.07 | 385.9 | .39 | .02 | 1499. |
| 20 | 13.07 | 32.09 | 20 | 24.16 | 377.6 | .77 | .08 | 1498. |
| 30 | 11.06 | 32.34 | 30 | 24.72 | 324.0 | 1.13 | .17 | 1491. |
| 50 | 8.70 | 32.37 | 50 | 25.13 | 284.9 | 1.72 | .41 | 1483. |
| 75 | 7.95 | 32.52 | 75 | 25.36 | 263.3 | 2.41 | .85 | 1481. |
| 100 | 7.64 | 32.81 | 99 | 25.63 | 238.2 | 3.05 | 1.41 | 1480. |
| 125 | 7.36 | 33.21 | 124 | 25.99 | 204.8 | 3.60 | 2.04 | 1480. |
| 150 | 7.16 | 33.48 | 149 | 26.22 | 183.0 | 4.08 | 2.72 | 1480. |
| 175 | 7.01 | 33.70 | 174 | 26.42 | 164.6 | 4.52 | 3.44 | 1480. |
| 200 | 6.89 | 33.88 | 199 | 26.57 | 150.2 | 4.91 | 4.18 | 1480. |
| 225 | 6.62 | 33.94 | 224 | 26.66 | 142.5 | 5.27 | 4.98 | 1480. |
| 250 | 6.29 | 33.95 | 248 | 26.71 | 137.6 | 5.62 | 5.82 | 1479. |
| 300 | 5.52 | 33.94 | 298 | 26.80 | 129.5 | 6.29 | 7.70 | 1477. |
| 400 | 5.03 | 34.02 | 397 | 26.92 | 118.9 | 7.54 | 12.13 | 1476. |
| 500 | 4.58 | 34.08 | 496 | 27.01 | 110.5 | 8.68 | 17.36 | 1476. |
| 600 | 4.25 | 34.14 | 595 | 27.10 | 102.6 | 9.74 | 23.31 | 1477. |
| 800 | 3.78 | 34.29 | 793 | 27.27 | 87.6 | 11.63 | 36.77 | 1478. |
| 1000 | 3.36 | 34.40 | 991 | 27.39 | 76.9 | 13.28 | 51.81 | 1480. |
| 1200 | 2.94 | 34.45 | 1188 | 27.47 | 69.5 | 14.73 | 68.11 | 1481. |
| 1500 | 2.42 | 34.53 | 1484 | 27.58 | 59.6 | 16.64 | 94.36 | 1484. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-121

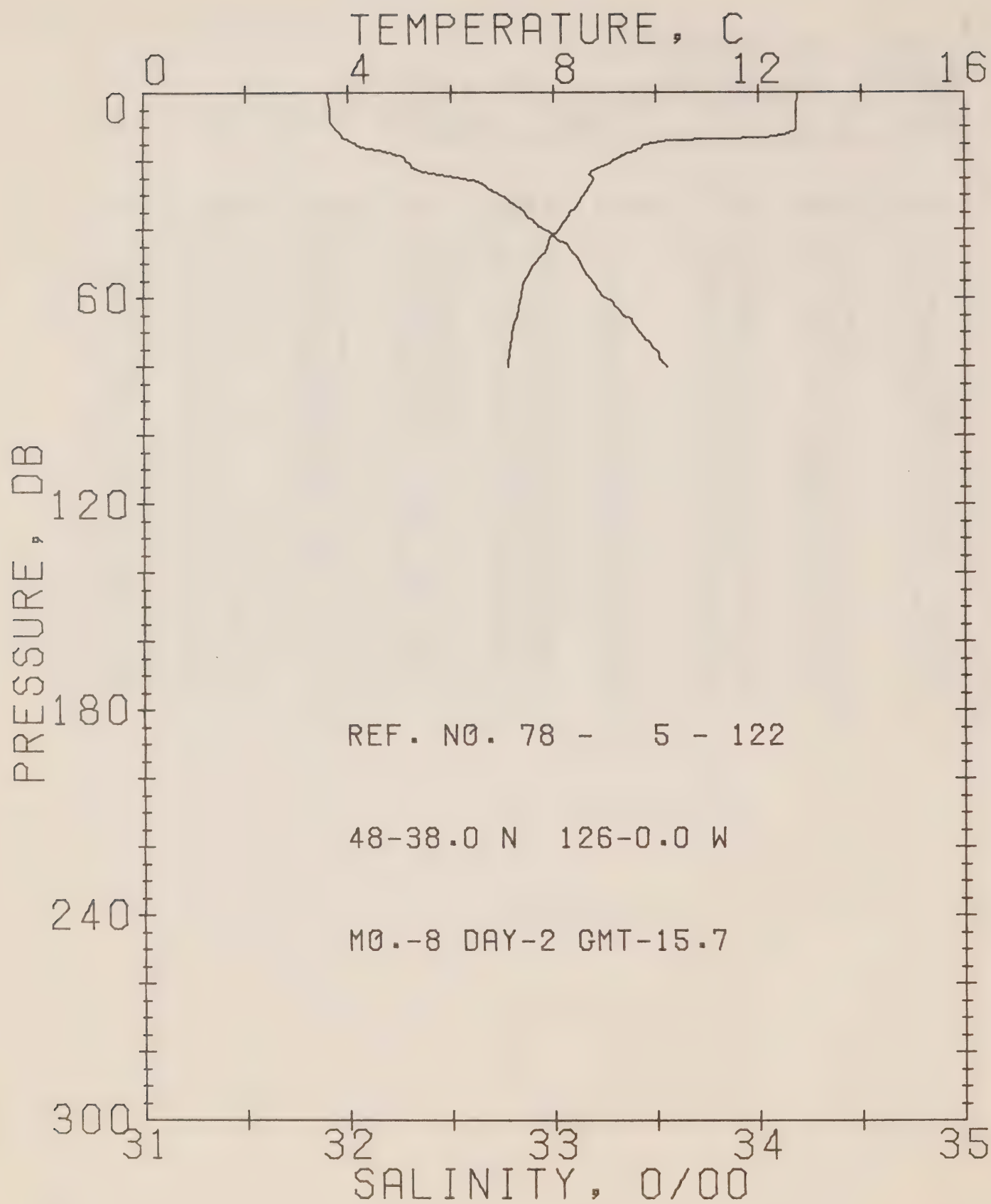
DATE 2/ 8/78

POSITION 48-42.0N, 126-40.0W GMT 13.0

RESULTS OF STP CAST 273 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 12.87 | 32.30 | 0 | 24.35 | 358.3 | .00 | .00 | 1497. |
| 10 | 12.61 | 32.30 | 10 | 24.40 | 353.8 | .36 | .02 | 1496. |
| 20 | 10.24 | 32.31 | 20 | 24.84 | 312.5 | .69 | .07 | 1488. |
| 30 | 8.98 | 32.35 | 30 | 25.07 | 290.4 | .99 | .14 | 1484. |
| 50 | 8.41 | 32.52 | 50 | 25.29 | 270.0 | 1.55 | .37 | 1482. |
| 75 | 7.64 | 32.88 | 75 | 25.68 | 232.9 | 2.18 | .77 | 1480. |
| 100 | 7.36 | 33.28 | 99 | 26.04 | 199.1 | 2.72 | 1.25 | 1480. |
| 125 | 7.22 | 33.59 | 124 | 26.30 | 174.5 | 3.18 | 1.78 | 1480. |
| 150 | 7.08 | 33.77 | 149 | 26.46 | 159.7 | 3.59 | 2.36 | 1480. |
| 175 | 6.87 | 33.88 | 174 | 26.58 | 149.4 | 3.98 | 3.00 | 1480. |
| 200 | 6.54 | 33.93 | 199 | 26.66 | 141.7 | 4.34 | 3.70 | 1479. |
| 225 | 6.09 | 33.94 | 223 | 26.73 | 135.6 | 4.69 | 4.44 | 1478. |
| 250 | 5.93 | 33.96 | 248 | 26.76 | 132.4 | 5.02 | 5.25 | 1478. |
| 300 | 5.59 | 33.98 | 298 | 26.82 | 127.4 | 5.67 | 7.07 | 1477. |
| 400 | 4.76 | 34.00 | 397 | 26.94 | 116.8 | 6.90 | 11.43 | 1475. |
| 500 | 4.69 | 34.10 | 496 | 27.02 | 109.9 | 8.03 | 16.62 | 1477. |
| 600 | 4.39 | 34.18 | 595 | 27.12 | 101.3 | 9.08 | 22.51 | 1477. |
| 800 | 3.98 | 34.30 | 793 | 27.26 | 89.4 | 10.98 | 36.02 | 1479. |
| 1000 | 3.59 | 34.39 | 991 | 27.37 | 80.0 | 12.65 | 51.28 | 1481. |
| 1200 | 3.17 | 34.46 | 1188 | 27.46 | 71.8 | 14.18 | 68.47 | 1482. |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-122

DATE 2/ 8/78

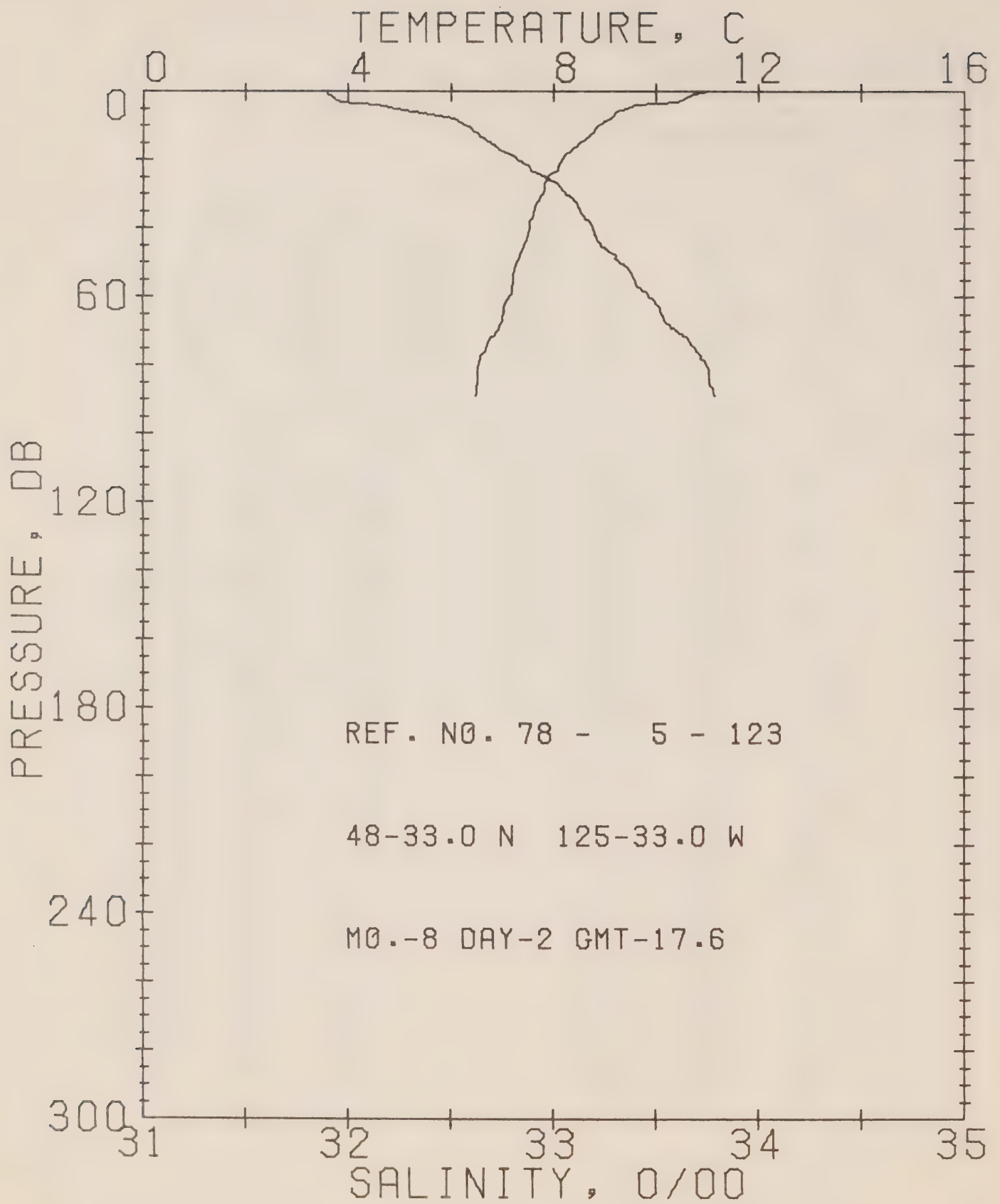
POSITION 48-38.0N, 126- .0W GMT 15.7

RESULTS OF STP CAST 55 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 12.78 | 31.90 | 0 | 24.06 | 386.1 | .00 | .00 | 1496. |
| 10 | 12.75 | 31.92 | 10 | 24.09 | 383.9 | .39 | .02 | 1496. |
| 20 | 9.20 | 32.28 | 20 | 24.98 | 298.6 | .72 | .07 | 1484. |
| 30 | 8.63 | 32.73 | 30 | 25.42 | 256.9 | 1.00 | .14 | 1483. |
| 50 | 7.66 | 33.13 | 50 | 25.88 | 214.1 | 1.47 | .33 | 1480. |
| 75 | 7.16 | 33.49 | 75 | 26.23 | 180.9 | 1.96 | .64 | 1479. |

| PRES | DEPTH | TEMP | SAL | PRES | DEPTH | TEMP | SAL |
|------|-------|-------|-------|------|-------|------|-------|
| | 0. | 12.78 | 31.90 | | 39. | 8.16 | 32.93 |
| | 5. | 12.76 | 31.91 | | 41. | 8.08 | 32.98 |
| | 6. | 12.76 | 31.91 | | 42. | 7.98 | 33.00 |
| | 9. | 12.75 | 31.91 | | 43. | 7.93 | 33.02 |
| | 11. | 12.74 | 31.94 | | 44. | 7.91 | 33.06 |
| | 12. | 12.61 | 31.96 | | 45. | 7.90 | 33.07 |
| | 13. | 12.15 | 31.97 | | 47. | 7.83 | 33.09 |
| | 14. | 10.30 | 32.00 | | 48. | 7.75 | 33.11 |
| | 15. | 9.79 | 32.04 | | 50. | 7.65 | 33.13 |
| | 16. | 9.73 | 32.06 | | 51. | 7.61 | 33.14 |
| | 17. | 9.63 | 32.18 | | 53. | 7.53 | 33.16 |
| | 18. | 9.41 | 32.22 | | 54. | 7.50 | 33.17 |
| | 19. | 9.34 | 32.27 | | 56. | 7.42 | 33.20 |
| | 20. | 9.18 | 32.28 | | 59. | 7.40 | 33.23 |
| | 21. | 9.12 | 32.30 | | 61. | 7.37 | 33.28 |
| | 22. | 8.90 | 32.31 | | 65. | 7.30 | 33.34 |
| | 23. | 8.75 | 32.36 | | 66. | 7.27 | 33.38 |
| | 24. | 8.73 | 32.44 | | 67. | 7.26 | 33.38 |
| | 25. | 8.80 | 32.56 | | 70. | 7.21 | 33.42 |
| | 26. | 8.78 | 32.63 | | 72. | 7.19 | 33.45 |
| | 27. | 8.75 | 32.65 | | 73. | 7.18 | 33.47 |
| | 29. | 8.67 | 32.70 | | 74. | 7.17 | 33.48 |
| | 31. | 8.57 | 32.77 | | 76. | 7.15 | 33.51 |
| | 32. | 8.54 | 32.79 | | 77. | 7.15 | 33.51 |
| | 34. | 8.43 | 32.84 | | 78. | 7.13 | 33.52 |
| | 35. | 8.33 | 32.86 | | 79. | 7.12 | 33.53 |
| | 36. | 8.31 | 32.87 | | 80. | 7.11 | 33.55 |
| | 38. | 8.22 | 32.91 | | | | |



OFFSHORE OCEANOGRAPHY GROUP

REFERENCE NO. 78- 5-123

DATE 2/ 8/78

POSITION 48-33.0N, 125-33.0W GMT 17.6

RESULTS OF STP CAST 64 POINTS TAKEN FROM ANALOG TRACE

BISSETT-BERMAN WAS USED DEPTHS ARE INPUT

| PRESS | TEMP | SAL | DEPTH | SIGMA T | SVA | DELTA D | POT. EN | SOUND |
|-------|-------|-------|-------|------------|-------|------------|------------|-------|
| 0 | 11.04 | 31.90 | 0 | 24.38 | 355.5 | .00 | .00 | 1490. |
| 10 | 8.93 | 32.56 | 10 | 25.24 | 273.8 | .31 | .02 | 1483. |
| 20 | 8.21 | 32.82 | 20 | 25.56 | 243.9 | .57 | .05 | 1481. |
| 30 | 7.81 | 33.06 | 30 | 25.80 | 221.1 | .80 | .11 | 1480. |
| 50 | 7.32 | 33.32 | 50 | 26.07 | 195.3 | 1.22 | .28 | 1479. |
| 75 | 6.71 | 33.68 | 75 | 26.44 | 160.7 | 1.67 | .57 | 1477. |

| PRES | DEPTH | TEMP | SAL | PRES | DEPTH | TEMP | SAL |
|------|-------|-------|-------|------|-------|------|-------|
| | 0. | 11.04 | 31.90 | | 46. | 7.41 | 33.25 |
| | 1. | 10.77 | 31.90 | | 47. | 7.40 | 33.27 |
| | 3. | 10.46 | 31.96 | | 48. | 7.36 | 33.31 |
| | 4. | 9.62 | 32.14 | | 49. | 7.34 | 33.30 |
| | 5. | 9.45 | 32.23 | | 51. | 7.27 | 33.35 |
| | 6. | 9.26 | 32.32 | | 52. | 7.26 | 33.37 |
| | 8. | 9.15 | 32.51 | | 54. | 7.22 | 33.39 |
| | 9. | 9.00 | 32.53 | | 56. | 7.22 | 33.40 |
| | 11. | 8.86 | 32.59 | | 57. | 7.21 | 33.41 |
| | 13. | 8.71 | 32.64 | | 59. | 7.19 | 33.46 |
| | 15. | 8.53 | 32.69 | | 60. | 7.14 | 33.47 |
| | 16. | 8.48 | 32.71 | | 61. | 7.11 | 33.49 |
| | 17. | 8.37 | 32.73 | | 62. | 7.06 | 33.50 |
| | 19. | 8.25 | 32.80 | | 63. | 7.05 | 33.52 |
| | 21. | 8.16 | 32.85 | | 64. | 7.04 | 33.52 |
| | 22. | 8.11 | 32.88 | | 67. | 7.02 | 33.54 |
| | 23. | 8.10 | 32.89 | | 69. | 6.97 | 33.57 |
| | 24. | 7.97 | 32.92 | | 71. | 6.86 | 33.63 |
| | 25. | 7.90 | 32.96 | | 72. | 6.77 | 33.65 |
| | 26. | 7.89 | 32.98 | | 74. | 6.73 | 33.67 |
| | 27. | 7.85 | 33.01 | | 75. | 6.69 | 33.69 |
| | 29. | 7.83 | 33.04 | | 76. | 6.66 | 33.70 |
| | 30. | 7.81 | 33.06 | | 77. | 6.60 | 33.72 |
| | 31. | 7.75 | 33.08 | | 78. | 6.59 | 33.72 |
| | 32. | 7.72 | 33.10 | | 79. | 6.57 | 33.74 |
| | 33. | 7.68 | 33.11 | | 81. | 6.54 | 33.76 |
| | 34. | 7.66 | 33.12 | | 84. | 6.53 | 33.76 |
| | 37. | 7.61 | 33.15 | | 85. | 6.53 | 33.76 |
| | 38. | 7.55 | 33.17 | | 86. | 6.52 | 33.77 |
| | 40. | 7.54 | 33.19 | | 87. | 6.52 | 33.78 |
| | 42. | 7.52 | 33.20 | | 88. | 6.51 | 33.78 |
| | 45. | 7.43 | 33.23 | | 89. | 6.49 | 33.79 |

Surface Salinity and Temperature Observations
(P-78-5)

SURFACE SALINITY AND TEMPERATURE OBSERVATIONS
CRUISE REFERENCE NUMBER 78- 5

| DATE/TIME | | | | SALINITY | TEMP | LONGITUDE |
|-----------|----|-----|------|----------|------|------------|
| YR | MO | DAY | GMT | 0/00 | C | WEST |
| 78 | 6 | 16 | 1815 | 31.060 | | 123-30 |
| 78 | 6 | 16 | 1935 | 30.790 | | 124- 0 |
| 78 | 6 | 16 | 2115 | 31.108 | | 124-30 |
| 78 | 6 | 16 | 2230 | 30.649 | | 125- 0 |
| 78 | 6 | 16 | 2355 | 31.879 | 13.5 | 125-33 |
| 78 | 6 | 16 | 2355 | 31.847 | 13.5 | 125-33 |
| 78 | 6 | 17 | 135 | 31.810 | 13.2 | 126- 0 |
| 78 | 6 | 17 | 135 | 31.858 | 13.2 | 126- 0 |
| 78 | 6 | 17 | 350 | 32.110 | 13.3 | 126-40 |
| 78 | 6 | 17 | 350 | 32.135 | 13.3 | 126-40 |
| 78 | 6 | 17 | 715 | 31.962 | 13.8 | 127-40 |
| 78 | 6 | 17 | 715 | 31.968 | 13.8 | 127-40 |
| 78 | 6 | 17 | 1115 | 32.253 | 12.8 | 128-40 |
| 78 | 6 | 17 | 1115 | 32.274 | 12.8 | 128-40 |
| 78 | 6 | 17 | 1505 | 32.404 | | 129-40 |
| 78 | 6 | 17 | 1750 | 32.342 | 12.8 | 130-40 |
| 78 | 6 | 17 | 2330 | 32.521 | | 131-40 |
| 78 | 6 | 18 | 230 | 32.516 | 12.2 | 132-40 |
| 78 | 6 | 18 | 610 | 32.602 | | 133-40 |
| 78 | 6 | 18 | 900 | 32.604 | 11.2 | 134-40 |
| 78 | 6 | 18 | 1255 | 32.600 | | 135-40 |
| 78 | 6 | 18 | 1540 | 32.663 | 10.2 | 136-40 |
| 78 | 6 | 18 | 1910 | 32.555 | | 137-40 |
| 78 | 6 | 18 | 2210 | 32.856 | 10.2 | 138-40 |
| 78 | 6 | 19 | 325 | 32.694 | | 139-40 |
| 78 | 6 | 19 | 620 | 32.724 | 9.7 | 140-40 |
| 78 | 6 | 19 | 1005 | 32.718 | | 141-40 |
| 78 | 6 | 19 | 1350 | 32.729 | 9.2 | 142-40 |
| 78 | 6 | 19 | 1855 | 32.704 | | 143-40 |
| 78 | 6 | 21 | 0 | 32.759 | 8.9 | ON STATION |
| 78 | 6 | 22 | 0 | 32.752 | 9.0 | ON STATION |
| 78 | 6 | 23 | 0 | 32.753 | 9.1 | ON STATION |
| 78 | 6 | 24 | 0 | 32.747 | 9.4 | ON STATION |
| 78 | 6 | 25 | 0 | 32.747 | 9.3 | ON STATION |
| 78 | 6 | 26 | 0 | 32.744 | 9.5 | ON STATION |
| 78 | 6 | 27 | 0 | 32.749 | 9.5 | ON STATION |
| 78 | 6 | 28 | 0 | 32.750 | 9.8 | ON STATION |
| 78 | 6 | 29 | 0 | 32.753 | 9.9 | ON STATION |
| 78 | 6 | 30 | 0 | 32.722 | 9.7 | ON STATION |
| 78 | 7 | 1 | 0 | 32.727 | 9.7 | ON STATION |
| 78 | 7 | 2 | 0 | 32.732 | 9.6 | ON STATION |
| 78 | 7 | 3 | 0 | 32.741 | 9.7 | ON STATION |
| 78 | 7 | 4 | 0 | 32.724 | 9.8 | ON STATION |
| 78 | 7 | 5 | 0 | 32.740 | 9.9 | ON STATION |

SURFACE SALINITY AND TEMPERATURE OBSERVATIONS
CRUISE REFERENCE NUMBER 78- 5

| DATE/TIME | | | | SALINITY | TEMP | LONGITUDE |
|-----------|----|----|------|----------|------|------------|
| YR | MO | DY | GMT | 0/00 | C | WEST |
| 78 | 7 | 6 | 0 | 32.737 | 10.2 | ON STATION |
| 78 | 7 | 7 | 0 | 32.735 | 10.4 | ON STATION |
| 78 | 7 | 7 | 1905 | 32.654 | 10.5 | ON STATION |
| 78 | 7 | 8 | 0 | 32.681 | 12.1 | ON STATION |
| 78 | 7 | 9 | 0 | 32.745 | 10.6 | ON STATION |
| 78 | 7 | 10 | 0 | 32.716 | 10.9 | ON STATION |
| 78 | 7 | 11 | 0 | 32.715 | 11.4 | ON STATION |
| 78 | 7 | 12 | 0 | 32.721 | 11.3 | ON STATION |
| 78 | 7 | 13 | 0 | 32.730 | 11.2 | ON STATION |
| 78 | 7 | 14 | 0 | 32.720 | 11.3 | ON STATION |
| 78 | 7 | 15 | 0 | 32.721 | 11.4 | ON STATION |
| 78 | 7 | 16 | 0 | 32.721 | 11.4 | ON STATION |
| 78 | 7 | 17 | 0 | 32.724 | 11.4 | ON STATION |
| 78 | 7 | 18 | 0 | 32.721 | 11.4 | ON STATION |
| 78 | 7 | 19 | 0 | 32.720 | 11.7 | ON STATION |
| 78 | 7 | 20 | 0 | 32.708 | 12.0 | ON STATION |
| 78 | 7 | 20 | 1745 | 32.717 | 12.0 | ON STATION |
| 78 | 7 | 21 | 0 | 32.716 | 12.1 | ON STATION |
| 78 | 7 | 22 | 0 | 32.716 | 12.3 | ON STATION |
| 78 | 7 | 23 | 0 | 32.704 | 13.4 | ON STATION |
| 78 | 7 | 24 | 0 | 32.734 | 12.0 | ON STATION |
| 78 | 7 | 25 | 0 | 32.707 | 12.5 | ON STATION |
| 78 | 7 | 26 | 0 | 32.704 | 12.7 | ON STATION |
| 78 | 7 | 27 | 0 | 32.702 | 12.6 | ON STATION |
| 78 | 7 | 28 | 0 | 32.699 | 12.6 | ON STATION |
| 78 | 7 | 29 | 0 | 32.638 | 13.0 | ON STATION |
| 78 | 7 | 30 | 0 | 32.641 | 12.6 | ON STATION |
| 78 | 7 | 31 | 0 | 32.676 | 12.6 | ON STATION |
| 78 | 7 | 31 | 640 | 32.614 | | 143-40 |
| 78 | 7 | 31 | 900 | 32.651 | 13.1 | 142-40 |
| 78 | 7 | 31 | 1230 | 32.688 | | 141-40 |
| 78 | 7 | 31 | 1500 | 32.671 | 13.2 | 140-40 |
| 78 | 7 | 31 | 1835 | 32.521 | | 139-40 |
| 78 | 7 | 31 | 2100 | 32.777 | 14.2 | 138-40 |
| 78 | 8 | 1 | 25 | 32.736 | | 137-40 |
| 78 | 8 | 1 | 255 | 32.382 | 14.9 | 136-40 |
| 78 | 8 | 1 | 625 | 32.505 | | 135-40 |
| 78 | 8 | 1 | 900 | 32.632 | 14.8 | 134-40 |
| 78 | 8 | 1 | 1200 | 32.472 | | 133-40 |
| 78 | 8 | 1 | 1500 | 32.493 | 15.7 | 132-40 |
| 78 | 8 | 1 | 2055 | 32.064 | | 131-40 |
| 78 | 8 | 1 | 2225 | 32.194 | 15.9 | 130-40 |
| 78 | 8 | 2 | 215 | 32.299 | | 129-40 |
| 78 | 8 | 2 | 510 | 31.975 | 15.6 | 128-40 |

SURFACE SALINITY AND TEMPERATURE OBSERVATIONS
CRUISE REFERENCE NUMBER 78- 5

| DATE/TIME | | | | SALINITY | TEMP | LONGITUDE |
|-----------|----|-----|------|----------|------|-----------|
| YR | MO | DAY | GMT | 0/00 | C | WEST |
| 78 | 8 | 2 | 510 | 32.024 | 15.6 | 128-40 |
| 78 | 8 | 2 | 850 | 32.058 | 13.9 | 127-40 |
| 78 | 8 | 2 | 850 | 32.100 | 13.9 | 127-40 |
| 78 | 8 | 2 | 1300 | 32.275 | 12.8 | 126-40 |
| 78 | 8 | 2 | 1300 | 32.300 | 12.8 | 126-40 |
| 78 | 8 | 2 | 1540 | 31.886 | 12.8 | 126- 0 |
| 78 | 8 | 2 | 1540 | 31.884 | 12.8 | 126- 0 |
| 78 | 8 | 2 | 1735 | 31.481 | 11.6 | 125-30 |
| 78 | 8 | 2 | 1735 | 31.078 | 11.6 | 125-30 |
| 78 | 8 | 2 | 1925 | 31.907 | | 125- 0 |
| 78 | 8 | 2 | 2045 | 31.192 | | 124-30 |
| 78 | 8 | 2 | 2205 | 31.215 | | 124- 0 |

* DENOTES SALINITY SAMPLE TAKEN FROM A
BUCKET. ALL OTHER SAMPLES TAKEN FROM
THE SEAWATER LOOP

LIST OF OMISSIONS

Hydrographic data:

| Consec. # | Depth (m) | T | S | O ₂ | 1 | 2 | 3 | Comments |
|-----------|-----------|---|---|----------------|---|---|---|----------|
| 68 | 173 | | * | * | | * | | |
| 86 | 1001 | | * | | * | | | |

Notes (MacNeill, 1977):

1. The data is suspect because of a reversal of gradient by greater than .01 ‰ (salinity) or greater than .08 ml/l (oxygen).
2. The data is deleted because of very irregular data values (usually a mis-tripping or leaking bottle if both oxygen and salinity are irregular).
3. The data is deleted because duplicate samples at a depth were not within .01 ‰ (salinity) or .08 ml/l (oxygen).

STD Data:

Note: Consecutive numbers 24 to 28, 61 to 65, and 96 to 100 are part of the MILE program and are not included in this report.

